- C1850-2
11/20/86

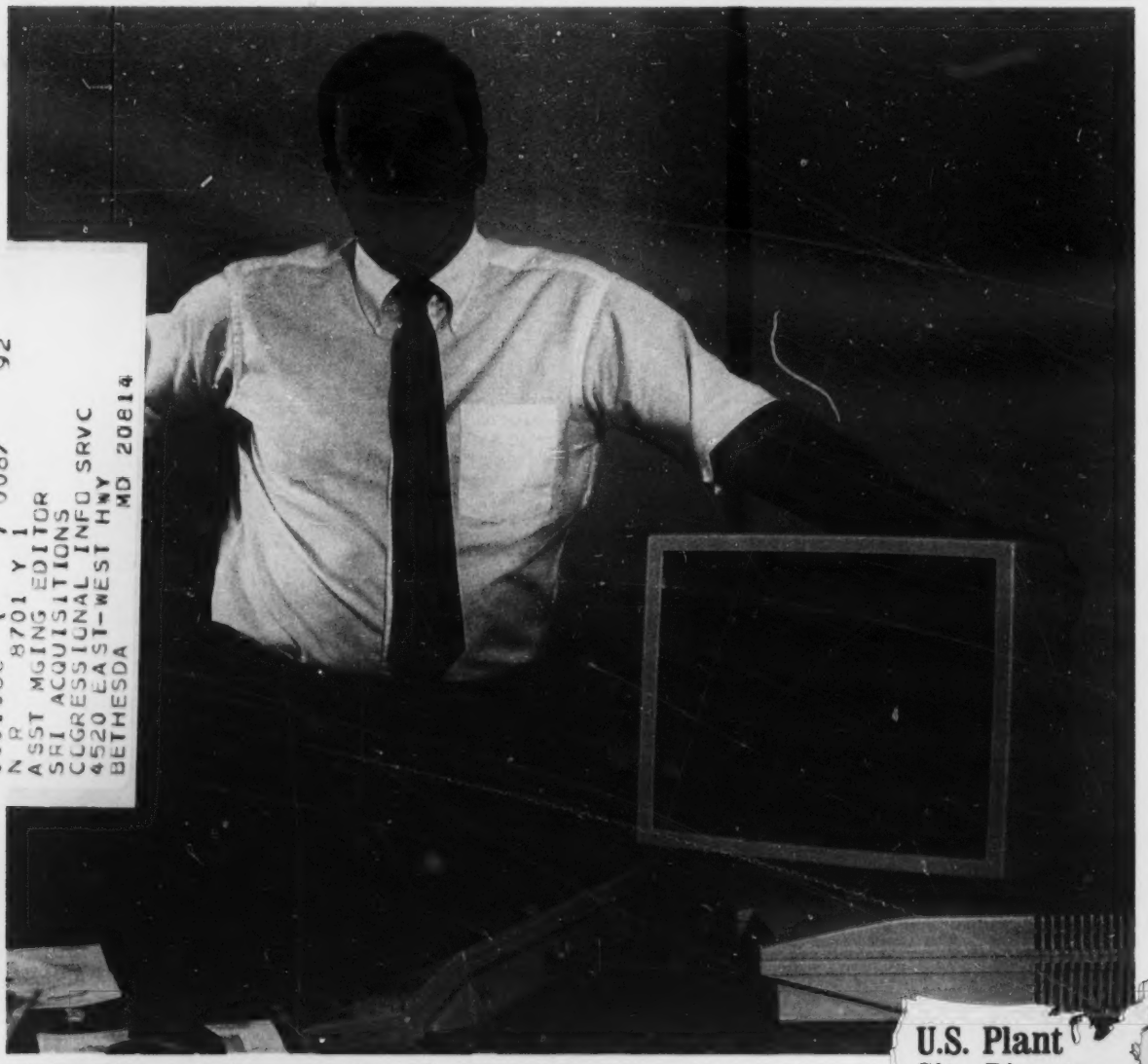
A CAHNERS PUBLICATION

NOVEMBER 15, 1986

Electronic Business

Managing Technology: Unix moves from myth to reality

Disk drives: More memory for workstation vendors



000186 ( ) 006/ 92
N R 8701 Y 1
ASST MGING EDITOR
SRI ACQUISITIONS
CONGRESSIONAL INFO SRVC
4520 EAST-WEST HWY
BETHESDA MD 20814

U.S. Plant Site Directory

Intergraph's Meadlock tackles CAE with a Clipper engine

Electronic Business

VOL. 12, NO. 22 NOVEMBER 15, 1986

THE BUSINESS MAGAZINE FOR THE ELECTRONICS INDUSTRY

PAGE 30

PAGE 44

PAGE 91

BUSINESS TRENDS

30 Automation: IBM puts MAP on the map in Endicott, N.Y.
In pilot project, IBM is wiring one of its oldest plants in a key test of MAP software on the factory floor.

38 Gramm-Rudman cast a pall over federal computer sales
U.S. computer makers did fine in fiscal 1986, but the prospects for 1987 are uncertain.

MANAGING TECHNOLOGY

72 Unix: Portable software for a stable market
After several false starts, Unix is the operating system of choice for numerous U.S. computer manufacturers.

82 Japan's new strategy in computer software
Japan's computer makers are developing their own standard operating system. It's not Unix. It's TRON.

MARKETS

62 Disk makers seek workstations access
Workstation vendors want gigabytes of storage for their design systems. Disk makers are a few megabytes shy.

MANAGEMENT

44 High-stakes poker in Huntsville, Ala.
Jim Meadlock, founder and president of Intergraph, is gambling on a new chip, workstation and strategy.

56 When you wish upon a Star Wars star
San Diego-based Titan Corp. has hired a top scientist away from SDI to help its military business.

DEPARTMENTS

4 Inside Business

9 Publisher's Memo

11 Update

19 Business Barometer: Fourth quarter's new products are next year's hopes.

24 Letters

110 Emerging Companies: MIPS Computer targets RISC chips for workstations.

111 Japan Report: Burroughs-Sperry: What the merger means in Japan.

114 Comment: Politics won't cure the U.S. chip industry's woes.

118 Calendar

120 Editorial Index

124 Viewpoint: To land on the market on time, designs must fly the first time.

U.S. PLANT SITE DIRECTORY

91 Introduction and guide to the plant site directory
This year's format pinpoints areas that offer favorable facilities to high-tech companies.

92 Regional comparisons of employment in electronics

93 High-tech vacancy rates and construction outlook

94 State employment rates in electronics and the salaries

100 Complete state-by-state directory of plant sites
Listing of business conditions, educational affiliations, services to new business and agency contacts.

100 Northeast
100 Atlantic
102 South
103 Midwest
105 Mountain
106 Pacific

AN EDITORIAL INDEX OF ALL COMPANIES DISCUSSED IN THIS ISSUE CAN BE FOUND ON PAGE 150

Cover photo/Bernd Billmayer

ELECTRONIC BUSINESS (ISSN 0163-6197) is published twenty-three times a year by Cahners Publishing, A Division of Reed Publishing USA, 275 Washington Street, Newton, MA 02158. William M. Platt, President; Terrence M. McDermott, Executive Vice President; Jerry D. Neth, Vice President of Publishing Operations; J.J. Walsh, Financial Vice President/Magazine Division; Thomas J. Dellamaria, Vice President Production & Manufacturing; Terrence M. McDermott, Group Vice President.

Copyright © 1986 by Reed Publishing USA, a division of Reed Holdings Inc.; Saul Goldweitz, Chairman; Ronald G. Segel, President and Chief Executive Officer. Advertising and editorial offices: Cahners Building, 275 Washington Street, Newton, MA 02158. Telephone: (617) 964-3030. Circulation offices: 270 St. Paul Street, Denver, CO 80206. Telephone: (303) 388-4511. Mailing list rentals: (312) 299-9311.

Second class postage paid at Denver, CO 80202 and additional mailing offices. Postmaster: Send address changes to ELECTRONIC BUSINESS, 270 St. Paul Street, Denver, CO 80206.
ELECTRONIC BUSINESS is circulated to managers of electronics companies. Subscription rates: U.S. and Canada $50 per year, all other countries $85 per year (including air mail). Single copy rates: U.S. $5.00, Canada and Mexico $6.00, Foreign $7.00. Cahners Publishing Company • A Division of Reed Publishing USA • Specialized Business Magazines for Building & Construction • Electronics & Computers • Foodservice • Manufacturing • Book Publishing & Libraries • Medical/Health Care.

VBPA ABP

Fourth quarter's new products are next year's hopes

PCs based on Intel's 80386 microprocessors are the industry's bet for growing production in 1987

The industrial production of computers and office equipment (SIC 357) in the United States continues to underperform the country's total industrial production. While the latter has been up slightly every quarter in 1986 with respect to last year, and is expected to finish the year almost 1% ahead of 1985, industrial production for SIC 357 has declined so far every quarter this year. Cahners Economics forecasts for 1986 a drop of almost 4% with respect to 1985.

IBM's signals confirm Cahners forecasts. Its domestic sales, consisting mostly of equipment produced in the United States, have been faltering throughout 1986. Moreover, even foreign sales, the engine that propelled most of IBM's growth this year, lost steam in the third quarter. Even with the help of a weaker dollar, IBM's third quarter revenue of $11.9 billion was ahead of last year's by only $200 million. Had the dollar been at the level it was last year, revenue would have been $1 billion smaller. The company's management does not expect any better news in the fourth quarter. On the other hand, Digital Equipment Corp., Big Blue's smaller but very successful rival, continues to increase sales by more than 10% with respect to 1985. For the four quarters that ended last June, Digital's sales grew almost 14%.

According to the same forecast, we must wait until next year for SIC 357 to mend its ways and go back, with a 7% increase, to its historical outperforming of the economy. This growth will be almost double the one Cahners expects for the whole U.S. industrial production.

Computer manufacturers plan to partake of that increase. The last quarter of this year is bringing a flurry of new product activity, from Apple Computer Inc. to Wang Laboratories Inc. If, as their makers hope, the new products attract demand, U.S. production will benefit because a good chunk of the new machines will be manufactured in this country.

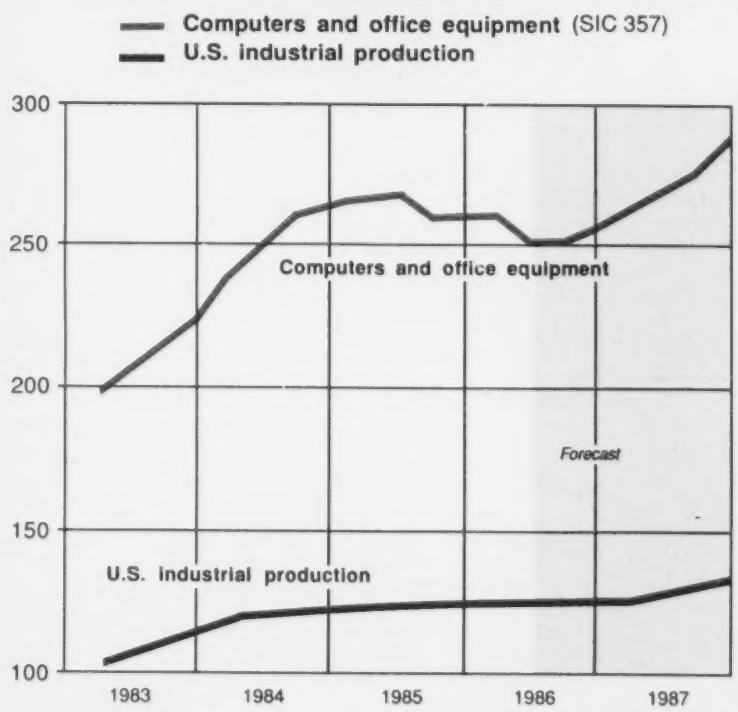
COMPAQ Computer Corp. led the way in that activity by introducing at the end of the third quarter the first personal computer that uses Intel Corp.'s new 32-bit microprocessor, the 80386. A host of companies, some established, some new, are readying similar machines for introduction in this quarter.

Big Blue itself is not expected to join the "386" fray until next year. By then, instead of using the Intel microprocessor, it may instead use custom chips which incorporate the 386 architecture. A new agreement with Intel gives IBM the means to do so. Moreover, a recent U.S. Supreme Court ruling in favor of Intel, which protects the copyright of a chip's microcode, gives IBM the means to fight would-be competitors who duplicate its computers by cloning its custom chips. In the meantime, IBM has aimed its new products at Digital, rather than at makers of PC clones. It introduced a medium size computer that can act as front end to, and is completely compatible with, its mainframe series 370. This is a U.S. product which probably will be successful and can, therefore, improve the chances for the computer industry in this country to match Cahners' forecast.

ALBERTO SOCOLOVSKY

Computers and office equipment

Industrial production indexes, 1977 = 100



Historical data: Federal Reserve Board
Forecast: Cahners Economics

Electronic components and accessories
Producer prices for electronic components rose 1.4% between October 1985 and March 1986, but then leveled off toward midyear. During the second quarter, a sluggish economy, when economic growth slowed to a crawl, marked a cutoff of end-user inventory accumulation which had fueled component market growth early in the year. Price levels inched up just 0.5% compared with the first quarter, the smallest gain since this industry's recovery began. Prices are expected to rise just 1.6% this year, down from a 2.4% rise last year. Orders will pick up again in 1987 and 1988, causing price pressures to build and resulting in annual gains of 2.8% and 3.6%, respectively.

Linear ICs
Producer prices for linear integrated circuits fell 1.2% in the second quarter from the prior quarter, or at a 4.7% annualized rate of decline. However, early reports for the third quarter point to more stable or perhaps slightly rising prices. This will help to reduce the annual decrease to approximately 4.2% from 6.3% last year. Prices should begin to experience a slight upward pressure by early 1987 but will be restrained by excess industry manufacturing capacity and continued low inflation rates in the United States. A modest 3.9% increase in prices is expected next year.

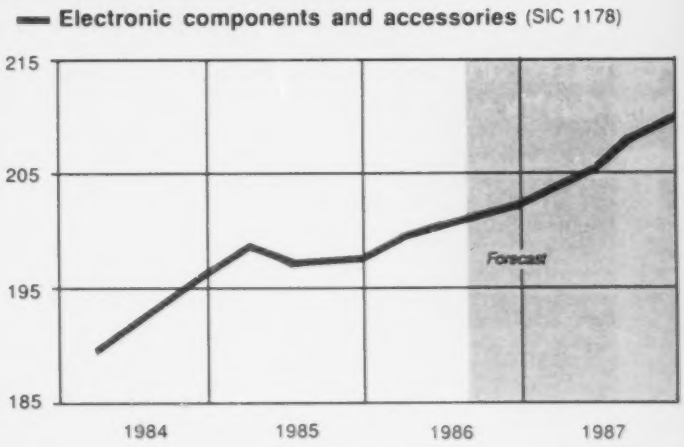
Digital bipolar ICs
Second-quarter prices for digital bipolar IC's jumped 4.1%, the sharpest increase since summer 1983 when the industry was in the midst of a strong expansion. The latest advance resulted from a rapid rise in customer order rates during late 1985 and early 1986. A summertime slump in the semiconductor market should temporarily alleviate this upward pressure, causing prices to slip below the second quarter's rate. Prices are now expected to average about 3.7% higher this year than they did in 1985. If customer markets show the expected improvement in 1987 and 1988, then prices will begin to climb again soon. We anticipate a rise of nearly 8% next year and a 6.2% increase during the following year.

Digital MOS ICs
Producer prices of digital MOS IC's increased 4.7% in this year's second quarter, reaching their highest levels since mid-1985. However, an interruption in the semiconductor industry recovery starting this spring and stretching into the fall is likely to bring more stable price trends in the second half of the year. Prices should begin to move up again once demand begins to rebound in early 1987. After tumbling 18% in 1985, prices are expected to decrease by a margin of 9.7% this year. This should be followed by increases of 6.2% and 2.3% in 1987 and 1988.

Producer price indexes

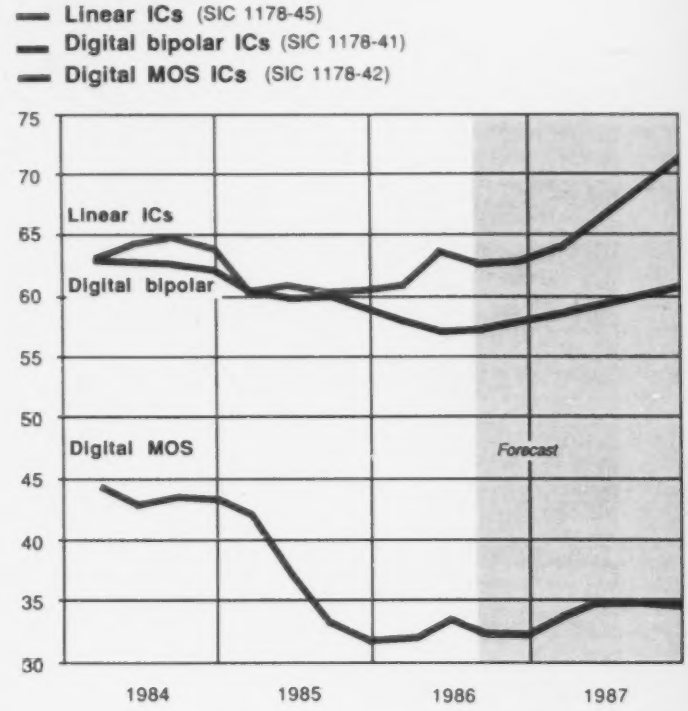
Electronic components

December 1967 = 100, quarterly averages



Integrated circuits

December 1974 = 100, quarterly averages



Historical data: Bureau of Labor Statistics
Forecast: Cahners Economics

Electrical machinery

The rate of capacity utilization in the electrical and electronic machinery industries continued to slow in the second quarter, dipping to an average 71.2% from 71.6% in the first quarter. Two factors placed downward pressure on the factory operating rate during the latest quarter: 1) lingering weakness in electronic component production, and 2) strike-related declines in the communication equipment market in June. Production resumed in the latter area during July, a fact which could push the rate back toward 72% in the second half of the year. Stronger improvements are expected to follow in 1987 and 1988, with the operating rate reaching 75% by the end of next year and about 80% by year-end 1988.

Instruments

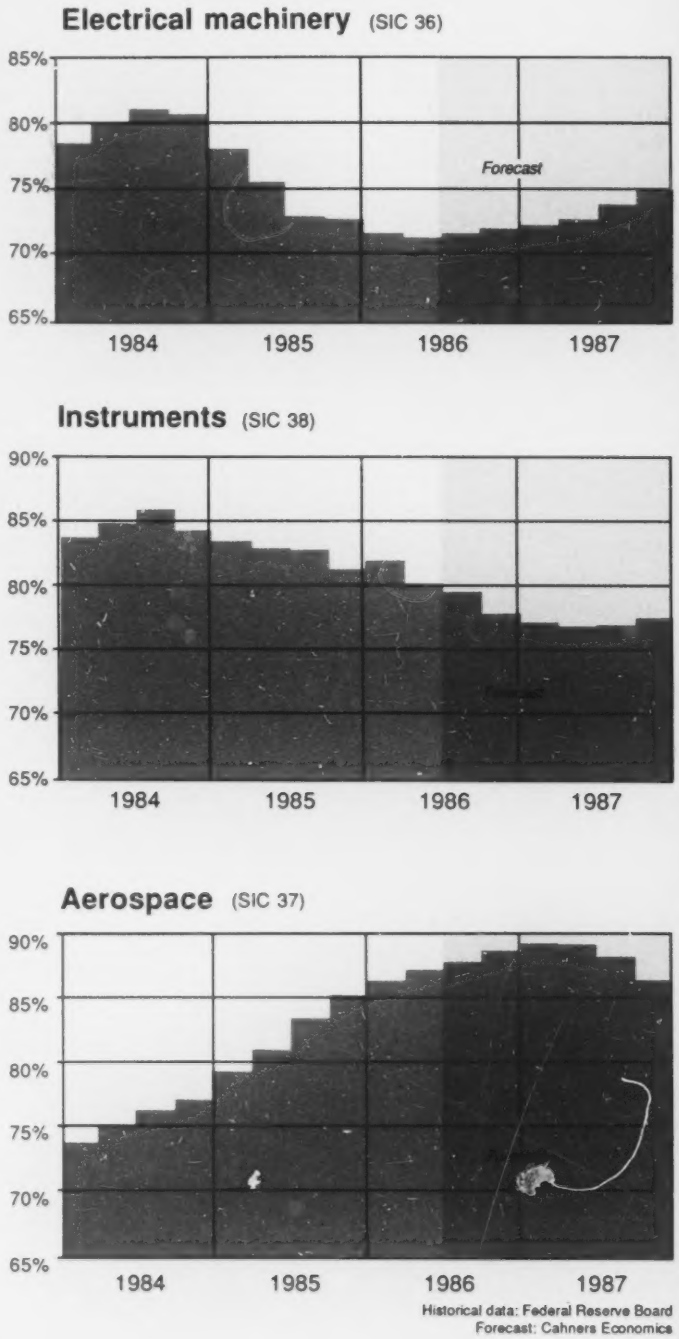
Instrument manufacturers operated at 80.5% of available capacity in the second quarter, down sharply from a rate of 82% in the first three months of the year. The loss reflected a 0.6% real quarterly decrease in production which was concentrated in a few large segments of the industry including watches, clocks and photographic equipment. A pick-up in U.S. business investment and quickening of consumer spending should help to reverse this downtrend by mid-1987. The operating rate is expected to finish 1986 at about 77%, dip below that level early next year, return to it by the end of 1987, and then show a gradual increase to about 81% over the course of 1988.

Aerospace

In the second quarter, manufacturers of aerospace equipment operated at 87.2% of capacity, a slight increase over the first quarter's 86.5% rate. Although defense spending has begun to slow under the weight of budget cutbacks, backlogs remain sufficiently high to sustain a strong rate of production in the aerospace industry for at least another year. Plant utilization is expected to increase steadily over the next several months, reaching a peak rate of close to 90% during the first half of 1987. Manufacturers should begin to scale back their production levels after that, cutting plant use to a level of about 82% by the end of 1988.

Plant utilization

Average percentage of capacity utilized per quarter



Historical data: Federal Reserve Board
Forecast: Cahners Economics

Automation: IBM puts MAP on the map in Endicott, N.Y.

In a pilot project, IBM is wiring one of its oldest plants in a key test of MAP on the factory floor

A portion of the production line for printed circuit boards at IBM's oldest manufacturing plant is in the process of becoming its most modern. In a pilot program at its Endicott, N.Y. facility, IBM is utilizing Manufacturing Automation Protocol (MAP) to tie together equipment from several leading automation vendors. The experiment could prove to be a key test of MAP as the communications link for factory automation.

For that reason, the results of the IBM pilot project will be closely followed, not only by printed circuit board makers, but also by companies who supply MAP-compatible equipment. With IBM's blessing, the market for MAP local area networks (LANs) — utilizing both broadband and carrierband technology — could climb to $369 million by 1990, about 78% of the total projected market for industrial LANs, according to Venture Development Corp., a market research firm in Natick, Mass. And in the words of one veteran automation analyst, "If IBM can't make this work, who can?"

The pilot is particularly important because General Motors Corp. (GM), the prime mover behind establishing MAP as a standard, has slowed its capital spending in factory automation, raising questions about the viability of MAP. Some analysts also raise questions about IBM's commitment to the technology.

Even if IBM does have questions, though, about the long-term viability of MAP, it is moving forward with the Endicott pilot. The project, which will be completed early next year, will attempt to link various stand-alone process monitoring systems so that an engineer, sitting at a personal computer (PC) in a separate building, can access information — either from a host mainframe or from a smaller computer, such as an IBM Series/1 minicomputer, on the factory floor.

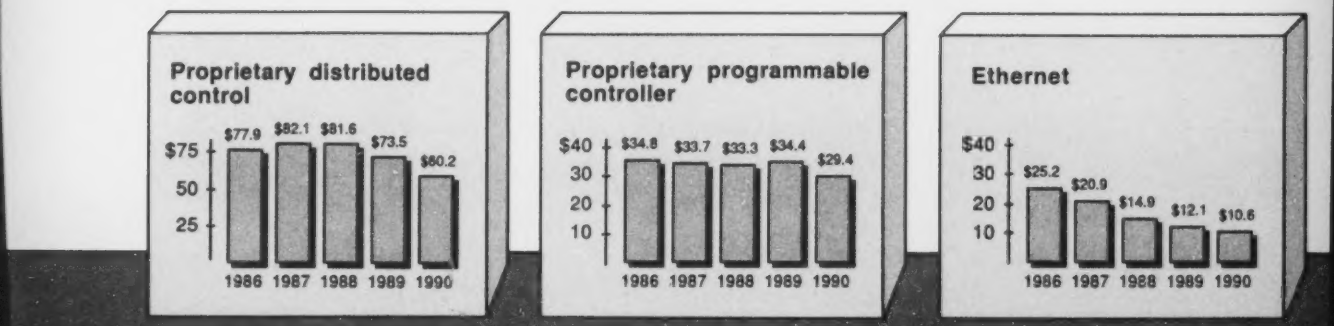
Presently, engineers must walk the factory floor at the Endicott facility — which manufactures advanced printed circuit boards for IBM's 3090 mainframe series — to obtain data on the manufacturing process. But if the MAP pilot works, the engineers will have access to all systems from a single PC, enabling them to more quickly monitor conditions on the line. Theoretically, this will translate into productivity gains down the road, since the company is implementing the pilot with an eye toward providing a means to incorporate additional MAP technology in future IBM products.

"This is an investment in the future," says Richard Sheftic, IBM's project leader for the pilot. "It can't be justified on an ROI [return on investment] sheet. The benefits are knowledge and experience." The Endicott plant, though, is primarily about IBM as a user of MAP technology and not a lab for the development of IBM's MAP products, Sheftic says. The pilot was not designed as an experiment, but as a working model. In fact, the production line has continued to operate at full capacity while the project team redesigns and rebuilds the line for MAP. When the conversion takes place, the line will shut down for only a few hours, Sheftic says. "We did not want to disturb the line in any way," he says.

A place for everything

The project encompasses four areas of advanced printed circuit board

Shipments of industrial local area networks segmented by network type ($ millions)



IBM's SHEFTIC: The Endicott pilot project is an investment in the future

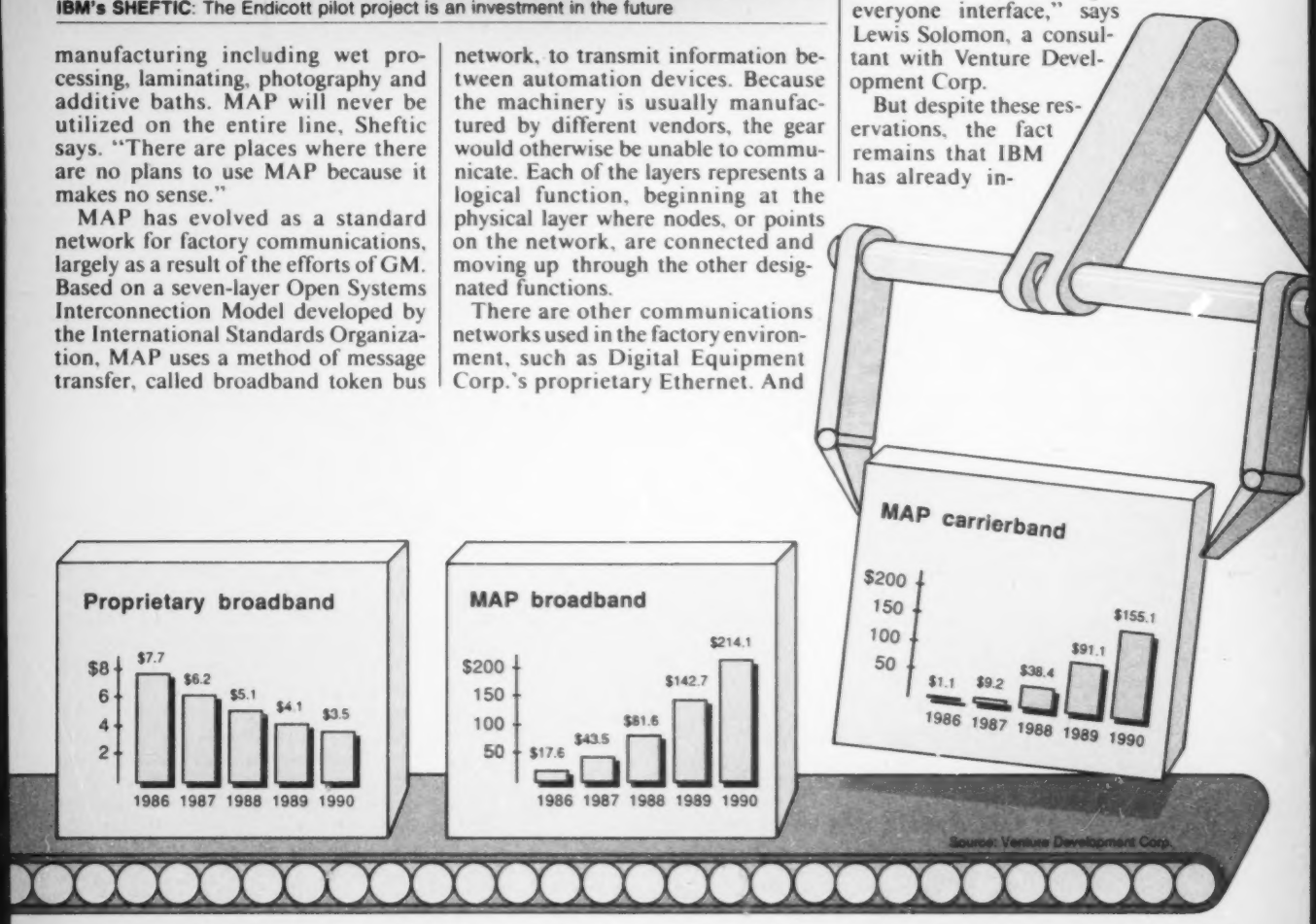
manufacturing including wet processing, laminating, photography and additive baths. MAP will never be utilized on the entire line, Sheftic says. "There are places where there are no plans to use MAP because it makes no sense."

MAP has evolved as a standard network for factory communications, largely as a result of the efforts of GM. Based on a seven-layer Open Systems Interconnection Model developed by the International Standards Organization, MAP uses a method of message transfer, called broadband token bus network, to transmit information between automation devices. Because the machinery is usually manufactured by different vendors, the gear would otherwise be unable to communicate. Each of the layers represents a logical function, beginning at the physical layer where nodes, or points on the network, are connected and moving up through the other designated functions.

There are other communications networks used in the factory environment, such as Digital Equipment Corp.'s proprietary Ethernet. And while MAP will not be the sole choice for factory networks, it seems clear the standard will be the most popular. But as was the case with robots, the use of MAP has developed slowly and taken more time to implement than some expected. It is that early experience with implementation which may prove to be a competitive advantage to IBM and other companies, such as Deere & Co., Eastman Kodak Co. and Boeing Co., which are also installing MAP pilots.

The Endicott pilot notwithstanding, though, some analysts question just how deep IBM's commitment to MAP really is. "They support it," says Robert Harbage, a senior consultant with the A.D. Little Co. in Cambridge, Mass. "But they're not moving as fast on it as some other people." There are also serious questions about whether MAP, which is above all else a standard aimed to permit the interconnection of equipment from all vendors, is in IBM's best interests. "I'm not sure IBM wants to be moving ahead to let everyone interface," says Lewis Solomon, a consultant with Venture Development Corp.

But despite these reservations, the fact remains that IBM has already in-



stalled the cable and made the physical connections in the Endicott plant, and is now involved in the tricky task of writing software — software it reportedly will later try to sell as a package with the Series/1. Marcia Brooks, a senior analyst with International Data Corp. in Framingham, Mass., thinks IBM may be using the Endicott project to promote the Series/1, a machine which she says may not be able to compete in the factory environment with the PC as a workcell controller.

For all its significance, the IBM MAP pilot is still limited in scope. Ideally, Sheftic says, a company would build a new line utilizing MAP. But he and IBM hedged their bets.

Too many unknowns

"There are so many unknowns about MAP, we tried to limit the number of variables," he says. "We're trying to move incrementally." For that reason, none of the equipment purchased from other vendors for the pilot will be tied directly to the broadband cable. That gear includes programmable logic controllers purchased from Rockwell International's Allen-Bradley Co. subsidiary and Texas Instruments Inc., and a data acquisition unit from Hewlett-Packard Co. This equipment will be meshed with an IBM 370 host computer and IBM Series/1 minicomputers on the shop floor which provide monitoring system data. Interfaces supplied by Concord Communications Inc. connect the minicomputers to the MAP broadband cable which is the information highway.

The purchase of this equipment from outside vendors, some observers say, is an indication of how serious IBM is about the Endicott project as well as a recognition of some of the company's own shortcomings in automating manufacturing plants. "They realize they can't do everything on the factory floor," says Solomon. "They're going to have the first insight, even before GM, of how to make it work, and how hard it is."

"We recognize that we must purchase equipment from other vendors," says Sheftic. "It's going to be a mixed-vendor environment, like GM's, out into the later '80's and early '90's." A.D. Little's Harbage, though, takes a different view of IBM's involvement with MAP. He sees the Endicott project more as an instance of IBM's caution than its daring. "They could be penalized for not being MAP-compatible," he says, and so they are going ahead with utilizing the communications protocol.

From his perspective on the shop floor, Endicott project manager Sheftic takes a pragmatic view of the MAP technology. "From a user's point of view, MAP is a tool," he says.

The pilot project, Sheftic admits, will be fairly primitive in that MAP has progressed since IBM committed itself to the project one year ago at the Autofact Show in Detroit. "You've got to remember," he says, "that this is an early MAP project." And there is still no telling exactly in what form the protocol will emerge.

Indeed, vendors frequently complain that the standard changes too rapidly to permit product development cycles. But no matter how primitive the system, and whatever the reasons behind it, the fact is that IBM will likely have one of the first automated plants utilizing MAP when others are still just talking about it.

FRED McGRAIL

DON'T BE HANDCUFFED
BY MARKET UNCERTAINTIES

In an unsure marketplace you need to react fast to changes.

You must make ever shrewder buying decisions and preserve capital. Especially in areas of rapidly changing technology. In test or design instrumentation and data communications equipment for instance.

U.S. Instrument Rentals helps by giving you flexible financing options that let you expense equipment, save capital, and reduce inventory. And you can even trade up as technology advances.

For your short-term needs we have inexpensive instrument rentals. For extended requirements we offer cancellable lease/purchase plans where you can build equity. Or straight purchase plans with low interest financing. Plus full service.

We stock thousands of the latest and best models. Each fully tested, calibrated (MIL-STD), and warranted. And we can deliver overnight.

Don't get locked in. Call for the key. U.S. Instrument Rentals. *The Company For Rent.*

800-824-2873

United States Instrument Rentals, Inc.

A U.S. Leasing Company
2988 Campus Drive
San Mateo, CA 94403
800-824-2873

Gramm-Rudman casts a pall over federal computer sales

U.S. computer makers did fine in fiscal 1986, but the prospects for 1987 are uncertain, due to deficit reduction

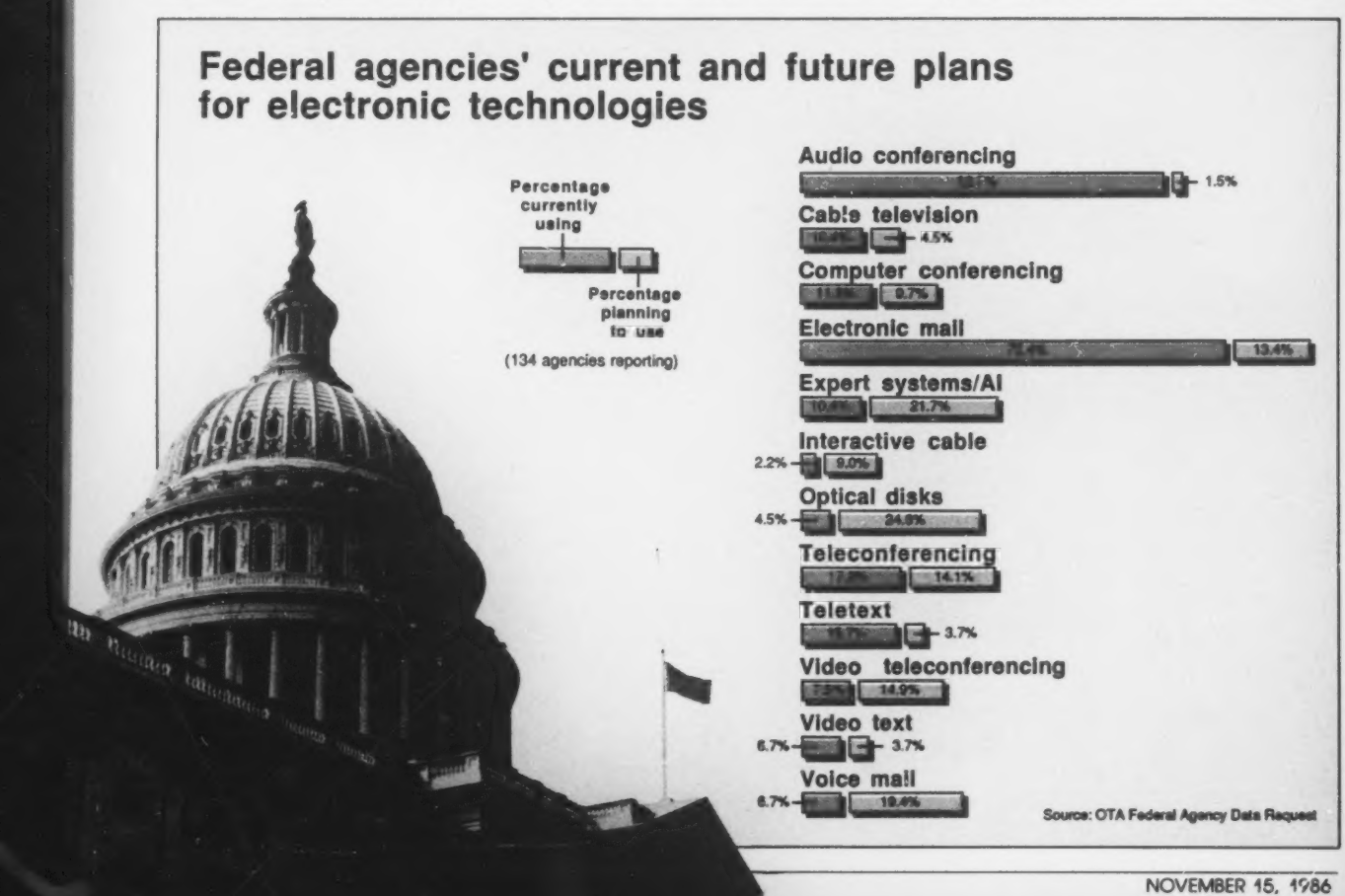
If the capital investment slowdown in the private sector was not bad enough, computer vendors now have to put up with another headache: Gramm-Rudman-Hollings. The deficit reduction act is expected to put a damper on federal computer sales in the coming year.

Harold "Hal" Julsen, vice president of marketing for Control Data Corp.'s Government Systems Group, for example, says CDC's sales level is "about the same for 1985 and 1986. But the apprehension over Gramm-Rudman has put lots of confusion into the market. We've seen the stretching out of programs, the canceling of them and lots more competition."

The impending impact of Gramm-Rudman looks particularly grim because, on the whole, computer makers did not make out too badly in the federal fiscal year that ended Sept. 31. Once the final figures for fiscal 1986 are tallied, analysts expect purchases of nonmilitarized general-purpose computers, peripherals and software by both the military and civilian federal agencies to have risen 15% over last year's approximately $14 billion level. Also, the Office of Management and Budget estimates that federal information-technology spending will reach $15.2 billion in fiscal 1986, a 4% increase over the previous year's figure.

The top five federal purchasers remain the same as last year, too: the Air Force, Army, Navy, the National Aeronautics and Space Administration (NASA) and the Department of Energy. Likewise, the type of products they are buying has not changed much. Mainframes and standalone microcomputers remained hot. (A recent Office of Technology study noted that the number of mainframes installed in federal agencies more than doubled between 1980 and 1985, to 27,000. During the same period, the number of mainframe terminals more than quadrupled to 170,000, while the number of microcomputers climbed from a few thousand to 100,000.)

Other big sellers last year were local area networks, the Unix operating system and Ada, the military's standard programming language. Supercomputers and database machines (computers optimized to run large-scale database management programs) increasingly seem to be making inroads into federal agencies as well. High-end equipment is doing well because agencies are being forced to get more bang for their data-processing buck as a direct result of Gramm-Rudman, according to Lem Wiggins, federal marketing manager of the Atlanta-based federal division of Teradata Corp., a leading manufacturer of database ma-



. . . Stay Ahead

Using FACTRON SCHLUMBERGER Series 900 Productivity Management with Growing Power

A system so flexible it offers a choice of hardware and software to precisely meet every process management need of your company.

A system that builds a powerful advantage over your competition and at the same time develops company skills.

A system that not only gives true production visibility and real time information, but helps trim down manufacturing costs.

An open architecture system that grows with your company to become a vital element in future Computer Integrated Manufacturing (CIM) development.

FACTRON SCHLUMBERGER Series 900 Productivity Management. Comprehensive tools to give perfect control.

Building Better Productivity

The Series 900 Productivity Management starting point is a worldwide partnership between DIGITAL EQUIPMENT CORPORATION and FACTRON.

Applying the immensely powerful, flexible and fast VAX/micro VAX range of super mini-computers, using industry standard computing and communication methods utilizing high speed, easily installed Ethernet networking, systems are applied into your own individual company requirements.

Hardware and software packages ranging from comprehensive off-line programming and test program library control to paperless repair and focused management reporting are available in any combination.

The advantages are clear. A powerful management system that brings test and repair information and control to your desk when you need it, identifying problems and fault trends quickly, improving both productivity and quality – and all in a package tailored to your company needs.

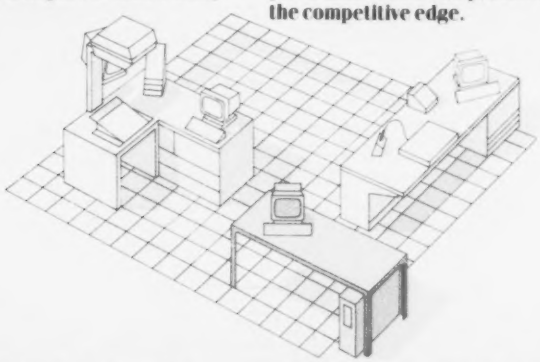
Your Company and FACTRON – A Productive Partnership

But FACTRON SCHLUMBERGER goes even further to help your production both now and into the future. A new level of support from people with a complete understanding of manufacturing and test problems. Engineering and applications teams in the U.S.A. and Europe, backed by support throughout the world. A comprehensive product range with applications specialization that covers computer, telecommunications, automotive, industrial and consumer manufacturing.

FACTRON SCHLUMBERGER Series 900 Productivity Management – With Growing Power

FACTRON Series 900 Productivity Management offers capability beyond the conventional. A powerful, uniquely flexible system of hardware and software modules that you can build with and grow to meet your company's future needs, ensuring long term growing power through an unbeatable partnership of FACTRON and you.

Phone FACTRON now – today. We'll prove that Series 900 products give you the competitive edge.



FACTRON SCHLUMBERGER, U.S.A: 299 Old Niskayuna Road, Latham, New York 12110. Tel: (518) 783-3600

FACTRON SCHLUMBERGER, Europe: Ferndown Industrial Estate, Wimborne, Dorset BH21 7PP, U.K. Tel: (0202) 893535
NISSEC SCHLUMBERGER, Japan: 1-2-10 Hirakawacho, Chiyoda-ku, Tokyo 102. Tel: (03) 2397411
SCHLUMBERGER SYSTEMS, Singapore: 12 Lorong Baker Batu, Singapore 1334. Tel: 7466344

BENELUX Holland Tel. (040) 457745. FRANCE Tel: (1) 4687 3243. GERMANY Tel: (089) 638110. ITALY Tel: (2) 9233474. SWEDEN (8) 699733

FACTRON AGENTS/DISTRIBUTORS
SPAIN Tel: (1) 2624913. SWITZERLAND Tel: (31) 442711. TURKEY Tel: (1) 338 3529

FACTRON
Schlumberger

Partners in Productivity

chines. "Government customers are embracing database machines faster than the commercial market," Wiggins says.

Control Data's Government Systems Group in Minneapolis also reports increased interest in higher power hardware. Government Systems concentrates on selling militarized products, but also offers general-purpose systems and services to the Department of Defense (DoD), NASA and other defense-related agencies. (CDC's commercial groups are charged with selling into most of the other agencies.) Accordingly, the Government Systems Group is investigating RISC (reduced instruction set computer) and fault-tolerant architecture, as well as "smaller, air-cooled, lightweight, powerful computers" in direct response to the federal government's demands, says group vice president Julsen. Government interest in its Cyber mainframe computers remains high, he says, and should be boosted even higher when CDC comes out with its Ada compiler for the systems in early 1987. And the ETA supercomputer, manufactured by CDC spinoff ETA Systems Inc., should be of great interest to NASA and the DoD after it debuts next year, Julsen predicts.

Supercomputers and database machines are making inroads

Digitial Equipment Corp.'s Government Systems Group also sees increased demand for its MicroVAX and cluster product lines. Purchases of the DECnet local area network and the company's Ada compiler also are going great guns, according to Frank Posey, manager of Government Systems. Ada, software designed specifically for military applications, "especially is picking up steam," Posey says. "It's our sixth fastest selling software product," he says.

Echoing the fears of other managers of federal systems divisions, Posey says he has not seen any fallout from the Gramm-Rudman bill. "It's a tougher competitive environment now," he concedes. "Not all of it's due to Gramm-Rudman. But we keep expecting it [Gramm-Rudman] to hit any time now."

MARY JO FOLEY

Foley is a Washington, D.C.-based business writer

High-stakes poker in Huntsville, Ala.

Jim Meadlock, founder and president of Intergraph, is gambling on a new chip, a new workstation and a new strategy

By David Card

In the foothills of the Great Smokies there is a little high-tech hamlet called Huntsville. Spawned by Werner von Braun's rocket crew, working out of the National Aeronautics and Space Administration's (NASA) Marshall Space Flight Center, this Alabama city is now the home of several major electronics companies, including contract manufacturer SCI Systems Inc. But the standout in town is Intergraph Corp., which — with its 44% five-year growth rate — is now the second largest supplier in the computer-aided design and manufacturing (CAD/CAM) market behind IBM.

But although publicly traded Intergraph had $526 million in sales last year, and its salesforce seems to favor pinstriped suits, just like the folks from IBM, the firm still has the feel of a small company. Intergraph execs entertain at the company's favorite restaurant, the Greenbrier Bar-B-Que, which stands in the middle of a cotton field. The house specialty is a dinner combo of fried catfish, pork barbecue and hush puppies. The restaurant still serves Dr Pepper.

Ex-IBM engineer James Meadlock, Intergraph's 52-year-old president and founder, who once designed flight computers for NASA's Saturn V and Titan II rockets, is a workaholic who runs a tight ship. He abandoned his house in a nearby town three years ago to build a new home less than a hundred yards from Intergraph's headquarters.

But today, because the company is too big to be run by one person, Meadlock recently decentralized the organization to give more authority to divisional leaders. "We'll be a billion-dollar company in two or three years, unless we really screw up," predicts John Gridley, vice president for finance.

But that, of course, is the central question at Intergraph today: Will the company screw up?

Until now, Meadlock and Intergraph have won rave reviews from Wall Street and industry watchers. "Meadlock is one of the few living geniuses around in this business," says Charles Foundyller, president of Daratech Inc., a Cambridge, Mass., CAD/CAM market-watching firm. "If you look at Intergraph, historically they've been ahead of the industry in adopting evolving standards," adds Peter Heymann of Drexel Burnham Lambert Inc.

In the early CAD/CAM years, when competitors, such as Applicon Inc. (now part of Schlumberger Ltd.) and Computervision Corp., were offering automated design systems based on proprietary hardware, Intergraph sold systems based on computers from Digital Equipment Corp. — the No. 2 computer player overall (yet No. 1 in the hearts of engineers). Then, in the early 1980s, Intergraph wrote additional software to run on DEC's new VAX family of high speed 32-bit superminicomputers. Not coinciden-

AT A GLANCE

Intergraph Corp.
Huntsville, Ala.

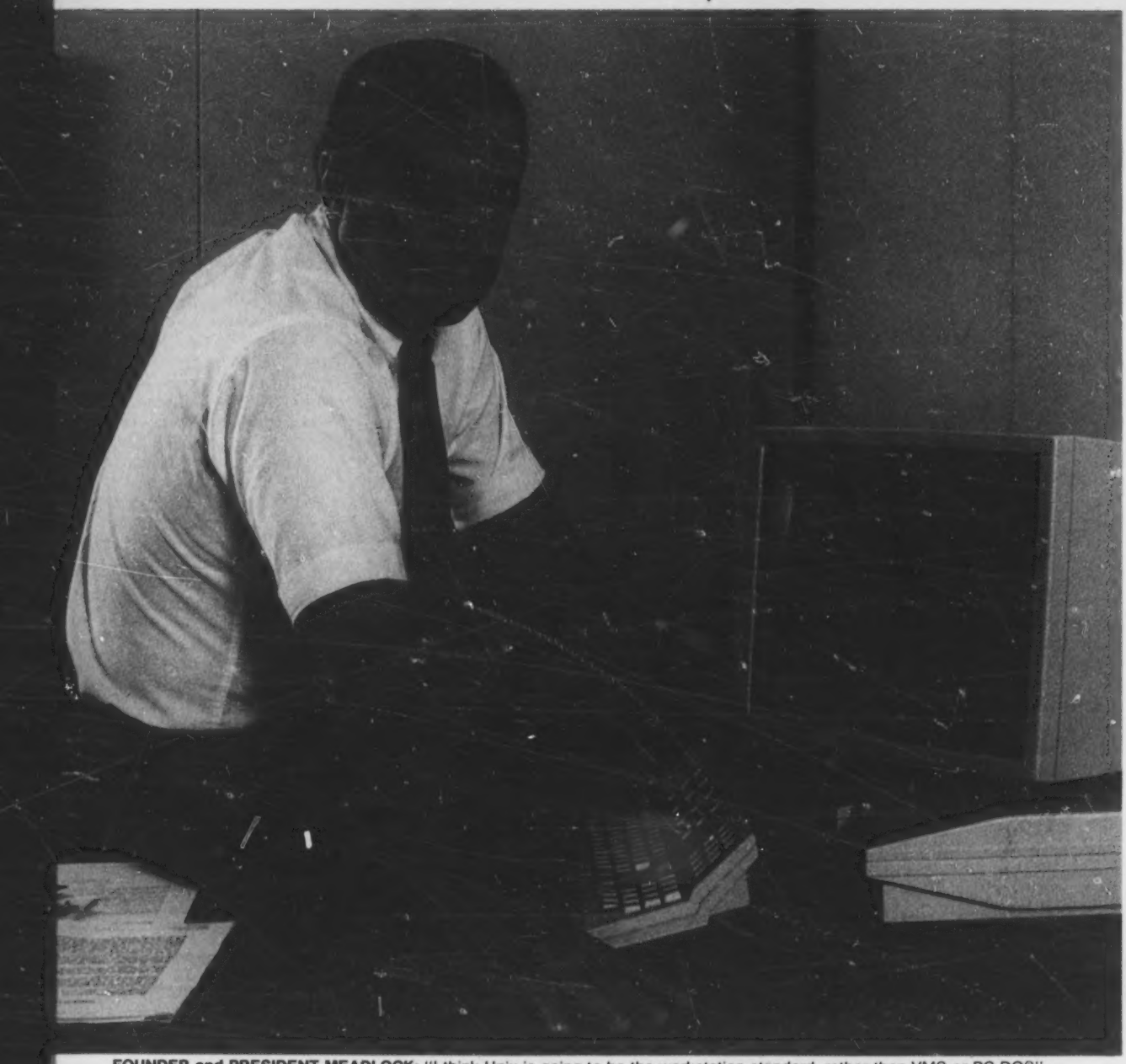
	FISCAL YEAR COMPARISON		
	1984	**1985**	**Change**
Sales ($ thousands)	$403,762	$526,405	+30.4%
Net income ($ thousands)	$62,936	$67,779	+7.7%
Net income/sales	15.6%	12.9%	–
Cost of sales/sales	47.3%	50.6%	–
R&D/sales	9.2%	9.6%	–
Marketing/sales	9.3%	10.7%	–
Capital expenditures/sales	5.6%	7.8%	–
Number of employees	3,700	5,100	+37.8%
Sales per employee	$109,125	$103,217	-5.4%
Net income per employee	$17,010	$13,290	+21.9%
Current ratio	2.63	4.37	–
Debt/equity ratio	0.04	0.03	–

Fiscal year ending December 31,

	MOST RECENT NINE MONTHS		
	1985	**1986**	**Change**
Sales ($ thousands)	$370,935	$448,354	+20.9%
Net income ($ thousands)	$49,093	$50,842	+3.6%

Nine months ending September 30,

Source: Dow Jones News/Retrieval



FOUNDER and PRESIDENT MEADLOCK: "I think Unix is going to be the workstation standard, rather than VMS or PC DOS"

Bernd Billmayer

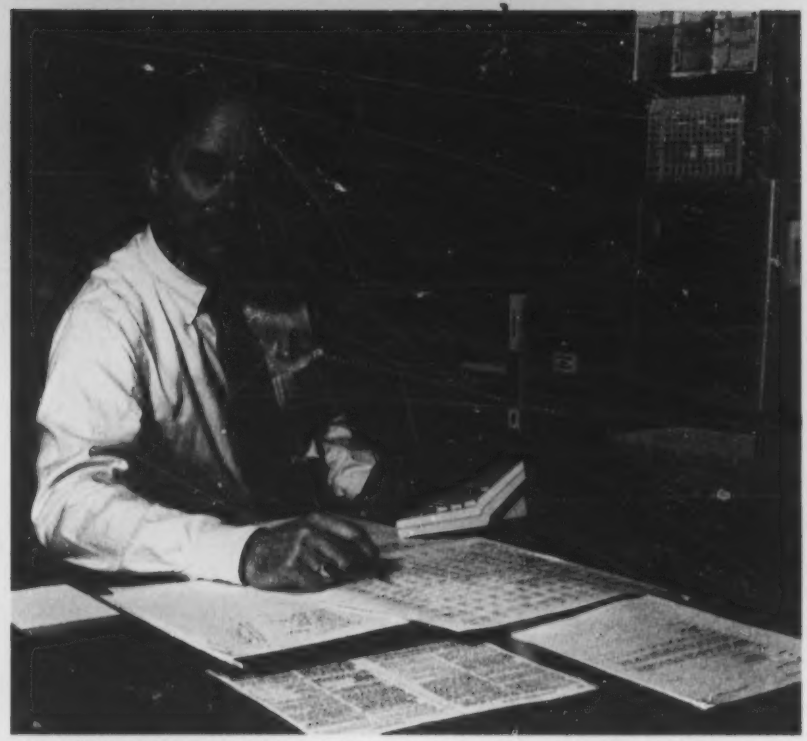
tally, Intergraph's sales took off.

In hindsight Meadlock's decision to follow DEC makes clear sense. The VAX is now an industry standard. But at the time it looked like a bit of a gamble. Now, Meadlock seems to be gambling again. He is moving Intergraph into a new market — computer-aided engineering (CAE) — and he is doing it on a new hardware engine. Intergraph, DEC's largest original equipment manufacturer (OEM), will continue to remain a DEC reseller, but will add to its hardware lineup its homemade Unix workstation, the Interpro 32. Both moves are bold, maybe too bold.

Meadlock says that the decision to move into CAE systems for printed circuit board (PCB) and integrated circuit design, and the decision to build its own computers are two separate issues at Intergraph. Coincidentally, CAE will also be the first test case for the Interpro workstation. So far, the company has only sold 1,000 workstations. But if the new Unix-based Interpro is a hit, it could prove that the Unix operating system — the software that controls the internal functions of a computer — can overcome the appeal of hardware labeled DEC or IBM. Other CAD/CAM companies, notably Computervision, are also migrating to Unix.

But critics, such as Frank Costa, a general manager at CAE rival Mentor Graphics Corp. calls Meadlock's belief that Unix is more important than the hardware it runs a "pipe dream." Meadlock, however, is not deterred. "I think Unix is going to be the workstation standard, rather than VMS [DEC's operating system] or PC DOS [IBM's]." Indeed, both DEC and IBM grudgingly support their own versions of Unix. But, if Meadlock is wrong, then he risks losing his momentum in CAD/CAM — maybe forever.

On top of this, the market that he picked to try out the new Interpro



VICE PRESIDENT for FINANCE GRIDLEY: "We'll be a billion-dollar company in two or three years, unless we really screw up"

presents plenty of problems. Electronic design, like other CAD/CAM markets, has slowed in recent months, one reason why Intergraph posted only modest growth in sales and earnings for the past two quarters. Moreover, although the electronic design market, totaling $800 million in 1985, is the fastest growing segment of the $3.6-billion CAD/CAM market, it is still an overcrowded field. CAE is just packed with aggressive start-ups such as Daisy Systems Corp. and Mentor Graphics, as well as bigger companies — Hewlett-Packard Co., IBM and Tektronix Inc. Although Meadlock is covering himself by keeping the bulk of Intergraph's offerings on various VAXs, the Interpro will be going head-to-head with DEC's own workstation, the VAXstation II GPX.

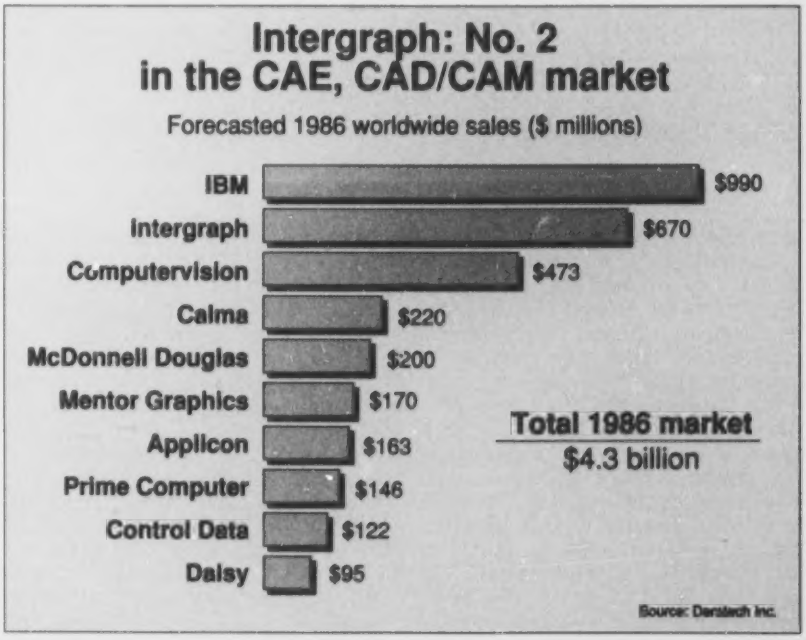
Also, this year in another gamble, Meadlock has souped up the Interpro to be more competitive with CAE workstations like the VAXstation by redesigning his machine's heart. The first version of the Interpro, introduced two years ago, was based on the National Semiconductor Corp. 32032 microprocessor, but sales were disappointing. Intergraph says that a lack of software held back the Interpro. Nevertheless, this year, Meadlock has switched microprocessors in midstream, moving from the National chip to the spanking new Clipper from Fairchild Semiconductor Corp. It remains to be seen, though, whether the Fairchild's architecture will have any greater impact than National's.

Meanwhile, there are some indications that Intergraph may face some tough competition in the year ahead. Xerox Corp., for example, helped get Intergraph started in the mechanical CAD/CAM business back in 1982. The Rochester, N.Y., copier division reportedly owns some $25 million worth of Intergraph equipment. But Xerox — Intergraph's largest mechanical customer, notes Meadlock — refuses to talk about future plans. Xerox execs say that the company is in the process of bringing on line its own CAD systems, courtesy of Xerox's Engineering Information Systems division in Santa Clara, Calif. The CAD/CAM market proved too attractive to pass up.

At Boeing Electronics Co., another Intergraph customer, there also may be problems. Boeing has two Intergraph VAX-based systems with 16 terminals for circuit board and hybrid design, according to Ronald Lemon, electronic CAD operations manager in Renton, Wash. Lemon says that the Intergraph tools are perfect for designing boards with surface-mounted components on them, something Boeing's older line of Computervision equipment could not handle. Service from the company, he says, is excellent. But, because Boeing has a heavy investment in Mentor machines, the company does not envision Intergraph as a workstation supplier, Lemon says. Lemon also does not currently see any real demand in the electronic design market for Unix.

A similar situation also seems to be taking place at Ford Motor Co., another Intergraph customer. Much of Ford's mechanical CAD/CAM gear is a combination developed jointly by Ford and the team of Prime Computer Inc. and Lundy Electronics & Systems Inc., according to Ford's executive engineer for engineering and administra-

Bernd Böhmayer



tive services, Basil Hooten. The Dearborn, Mich., auto maker also uses systems from Computervision and Daisy.

However, a Dearborn group is evaluating Intergraph equipment for PCB design, and a team, out of Ford Microelectronics Inc. in Colorado Springs, Colo., is interested in Intergraph's tools for designing hybrid circuits. Hooten says that Ford's current PCB software — from Harris Corp.'s Scientific Calculations Inc. subsidiary — does not quite "measure up to Intergraph." Likewise, Intergraph's hybrid-design package tested against a number of competitors, including Hewlett-Packard, and came out "the clear winner every time," according to Hooten. So far, so good.

The problems arise, not from Intergraph's performance but, from its choice of hardware. Intergraph's MicroVAX-based systems go over fine with Ford's engineers, but the auto maker's "corporate-computer gurus," Hooten says, have decided to standardize office automation (OA) on the IBM PC AT, and are leaning that way for engineering as well.

This month Ford should be finishing a 90-day study assisted by Arthur D. Little Inc. to decide if IBM will be the company standard. "The typical engineer in this company spends at least half his time in nontechnical work," Hooten says. "He needs an OA machine." The OA machine of choice is IBM's PC AT, "because there's so damned much third-party software running on it." So far Intergraph has been reluctant to do anything for the AT, Hooten says. "Who knows? Maybe we could twist their arm. We were hoping Arthur D. Little would convince them," he says,

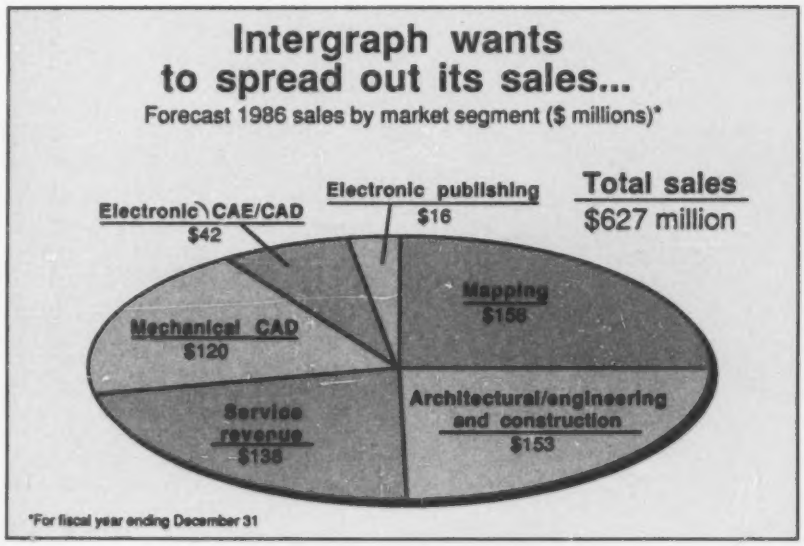
So for the time being, Hooten says, he considers Intergraph a niche supplier. Even though Ford is keen on Unix and open networking — two traditional IBM weaknesses, according to Hooten — IBM apparently has won out in office automation. It looks like management had enough confidence in IBM promises for future products to go with the big guy.

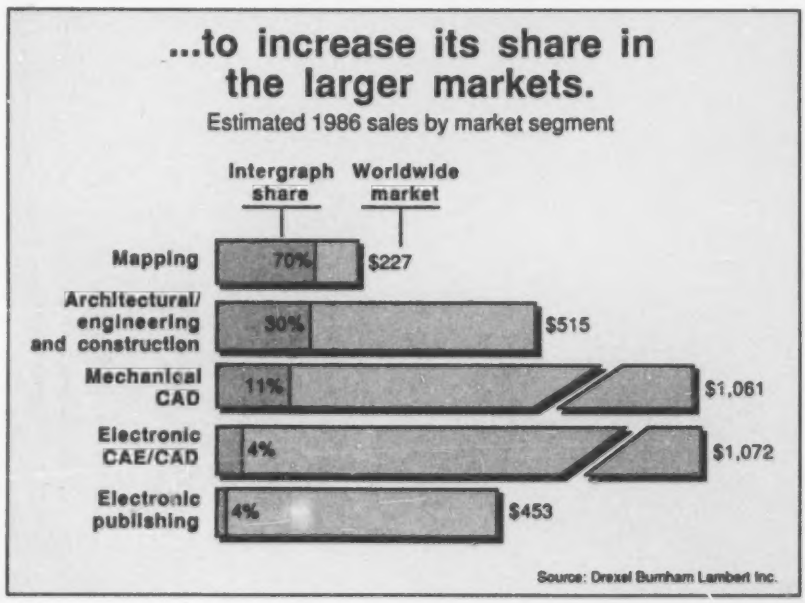
The big bet

When Intergraph successfully moved into mechanical CAD/CAM four years ago, it broadened its customer list. Today, Intergraph's customers include BellSouth Corp. and Phillips Petroleum Co. for computerized mapping systems, auto makers Volkswagen Do Brasil S.A. and Porsche AG for mechanical CAD, ROLM Corp. and Allied Signal Co.'s Bendix for circuit board design, Ford Motor Co. for plant design and Rockwell International Corp. for computer-aided publishing. Ideally, the company would like sales to be evenly distributed across its four major segments — mapping, mechanical CAD, electronics and architectural/construction design.

But some critics claim that Intergraph could be jeopardizing its position in these segments if the company decides to move into computer manufacture. "I can't understand why one of our significant competitors is doing what we just moved out of," says a puzzled Bardwell Salmon, marketing vice president for number three CAD/CAM supplier Computervision (CV). What Computervision just moved from was a propriety computer. CV had been making its own computer since 1977 and leading the CAD/CAM market with it, mostly in mechanical drafting and circuit board layout. Then as IBM and DEC-based Intergraph took off in the early 1980s, CV's fortunes declined. Last year this incompatible hardware strategy caught up with CV, and the Bedford, Mass., company lost $80 million and laid off a third of its workforce.

Now CV is in the midst of rewriting its software, all 6.5 million lines of it, to run under the Unix operating





system. This task is 85% done, according to CV's new president, Robert Gable. The resulting system will run on a workstation by Sun Microsystems Inc. Why build your own computer? Gable now asks rhetorically. "You're in danger of bringing out your own hardware, only to have it obsoleted one month later by a DEC announcement."

George Meister, a senior vice president at Manufacturing Industry Systems Co. (MISCO), part of aerospace giant McDonnell Douglas Corp., agrees. Last year, his company, which sells CAD software for Data General Corp., DEC and IBM computers, beat out Intergraph in a contract bid at Eastman Kodak Co. Customers prefer name-brand computers to machines built in-house, he says.

Strained relations

One reason Meadlock decided to build his own workstation, rather than resell DEC's machines, may have something to do with its overall relationship with DEC. Tension between the two companies is almost inevitable, analysts say, as DEC, which once sold almost exclusively through the original equipment manufacturing (OEM) market, moves slowly toward end-user sales.

Meadlock admits as much. "As we get bigger, we compete more with them. DEC also is not as OEM-oriented as they were 10 years ago and that causes some strains. But I think we've both recognized the territory we're treading and we've adjusted to it," he says. Moreover, Meadlock believes while most engineers want workstations, they also need bigger machines for data storage. This is where DEC fits in. "I don't plan to *not* buy VAXs," he concludes.

Ironically, if DEC had been able to

Sailing away on the Fairchild Clipper

Building its own computer is not Intergraph's only controversial strategy. The way it went about it is raising some eyebrows, too.

Critics, for example, question Intergraph's choice of the Clipper microprocessor of Fairchild Semiconductor Corp. to power the Interpro 32C workstation, especially since the original Interpro was based on National Semiconductor Corp.'s 32032. Intergraph spent some $10 million to switch chips, estimates Shearson Lehman Brothers Inc. analyst James Stone.

Intergraph electronics marketing manager Harold Barbour contends that, since its introduction in September 1984, a lack of software — rather than any problems with the computer or its chip — has kept the Interpro's sales at a disappointing 1,000 units. The National-based Interpro has been selling as a terminal for VAX-based applications. Now, he says, all Intergraph's electronics computer-aided engineering (CAE) packages are available.

But to broaden the Interpro's appeal, Intergraph, now offers a workstation based on Fairchild's 32-bit chip. Intergraph's executive vice president for engineering, John Thorington, is quick to say Intergraph has not abandoned National. Intergraph will sell both versions — the Clipper will be postioned as a high-end $25,000 machine, the National as a $15,000 entry model — and they both run the same software.

National says that there are no hard feelings. "Basically, what we consider the volume workstation business that Intergraph will be doing is still 32000-based," says Anne Wagner, marketing director for the 32000 line. "They are still good customers," she says of Intergraph, "they take a lot of product." Wagner says Intergraph is committed to volume purchase agreements, and that National recently upgraded Intergraph's Unix license.

"We have to position ourselves where we don't care where the chip comes from," Thorington says. The Interpro's architecture specifically separates the CPU, permitting easy chip switches. Since there was no Clipper in the winter of 1983, when the first specs were drawn up for the Interpro, Intergraph chose National for its floating point capability, Thorington says. Last year, the Clipper's 5-million instructions per second (MIPS) speed and floating point won him over.

The sheer elegance of the Clipper charmed Thorington. He says that Fairchild "finessed rather than brute-forced" the speed into the chip. He explains that he means

Bernd Böhmeyer

EXECUTIVE VICE PRESIDENT for ENGINEERING THORINGTON: "We have to position ourselves where we don't care where the chip comes from"

get to market faster with its own machine, then Intergraph might be reselling DEC workstations today. DEC "was so late we really couldn't wait for them," Meadlock recalls. He says that DEC had an early workstation project that was "decimated" on two separate occasions by defections to Apollo Computer Inc., the company that first pioneered the concept of engineering workstations.

Maybe Meadlock should have waited, though. DEC may have been late to the market, but it looks like, once again, it may have set an industry standard. To date, Intergraph has sold only 1,000 Interpros, compared with DEC's VAXstation II, which should reach calendar year sales of 10,000 units, according to market reseach firm International Data Corp. in Framingham, Mass.

Meadlock, however, apparently had no qualms about moving into computer manufacturing. No novice in hardware design, Intergraph has always manufactured its own products to add on to DEC systems, including a line of sophisticated intelligent graphics terminals. Also, the company only buys the heart of a VAX from DEC; as much as 85% to 90% of the systems that Intergraph sells are made in Huntsville.

Hardware content is one of the things that has kept Intergraph's gross profit margins in the 60% range, Meadlock says, and he intends to keep it that way. "The only way to be successful at this size is not to sell only software," he says. Meadlock sees three kinds of CAD/CAM companies: software (what he imagines most companies will be), hardware (DEC, IBM, potential Japanese entrants and maybe Apollo and Sun) and those that sell both.

Margins are not the only reason. Meadlock fears for any company that loses control of the total system. "Look at Daisy," he says, a CAE startup which has recently suffered several poor financial quarters. "They've tried to do their own [hardware], they've tried to put it on DEC's, on IBM's, and they've just been flopped off the wall."

So why does Meadlock think he can succeed with his own machine when other CAE companies have failed? The answer is easy, Meadlock says. He claims he has the best workstation on the market. "Right now nobody's in the same league," he says. And some analysts agree. James Stone of Shearson Lehman Brothers Inc. calls the Interpro 32C (due to start shipping in volume this quarter) "a fantastic piece of hardware." He says that its 5 MIPS (million instructions per second) performance and $25,000 price tag combine for twice the price/performance ratio of anything from Apollo, DEC or Sun, the three major workstation suppliers. Or IBM, for that matter. Intergraph may have a little trouble convincing customers to deny DEC or IBM but Stone says that, "Against two times price/performance, principles may give a little bit."

If Meadlock is correct in his timing, adds analyst Heymann at Drexel, the industry is just at the point where it will start to accept generic Unix-based hardware. Meadlock is just "keeping his foot in the door with DEC, while he completes the Unix shift," Heymann says.

Meanwhile, Daratech's Foundyller suggests that Meadlock may be looking even further ahead beyond the CAD/CAM industry. One day, he suggests, Meadlock may want to turn Intergraph into a mainstream computer company. But Meadlock says he is not interested in such grandiose schemes. He is just a simple country boy who wants to overtake IBM in CAD/CAM and CAE. □

Fairchild used rather ordinary process technology — 2 micron CMOS — and squeezed the performance into the Clipper via its architecture. The design combines reduced- and complex-instruction sets computer features into a supercomputer-type scheme. That description is not surprising, considering the Fairchild design team came from Cray Research Inc.

Thorington says he shopped around briefly last summer, meeting with Motorola Corp. and MIPS Computer Systems Inc. the same week before settling on Fairchild. Motorola powers the workstations of Apollo Computer Inc. and Sun Microsystems Inc. The MIPS chipset will be the guts of new machines from Prime Computer Inc. and Silicon Graphics Inc.

The Clipper module is packed with surface-mounted components to take the same space as the National chip-set. Fairchild had coincidentally used the same compilers and code generators as National, so the Unix match was very close.

Thorington says that Intergraph worked much more closely with Fairchild than with National, or DEC for that matter. Fairchild marketing director Tom Miller calls the resulting Intergraph/Fairchild relationship almost Japanese in character. There is a two-year joint development and volume purchasing agreement now, but during earlier stages no money changed hands. Fairchild is also debugging the Clipper on six Interpros, moving its CAE/CAD setup from a variety of vendors over to Intergraph.

Fairchild already has plans for the Clipper architecture that permit an upgrade path of 15 MIPS to 30 MIPS. □

What Intergaph brings to the CAE party

What Intergraph Corp. brings to CAE — besides an entire electromechanical design set-up from the same supplier — is an object-oriented database.

The chief benefit of the database, according to Intergraph, is what the industry calls a correct-by-construction approach. That is, a set of design rules that are incorporated into the objects of the database. Rather than completing a design and then sending it off to a larger computer for rule-checking, the object informs the engineer if he is violating a rule when he violates it, eliminating an extra step. The complexity of such an approach requires the high performance of the Interpro.

"It's head and shoulders above anything everybody else in the business has," says L.F. Rothschild, Unterberg, Towbin's Peter Schleider. Competitor William Parzybok, in charge of Hewlett-Packard's CAE effort until a recent reorganization, calls it one of the only two modern database systems on the market. The other, of course, is HP's — acquired when HP bought start-up Cericor Inc., a company Intergraph was once interested in, too.

Intergaph's other CAE pieces include integrated circuit layout tools from 50%-owned Tangent Systems Corp. and simulation software for analog chips from wholly owned Circuit Tools. □

Disk makers seek workstation access

Workstation vendors want gigabytes of storage for their design systems. The disk makers are a few megabytes shy

By Anne Knowles

Most manufacturers of scientific and engineering workstations would be happy with a gigabyte of disk drive memory in their machines. But most workstation makers, like Apollo Computer Inc. and Sun Microsystems Inc., have had to settle for a combination of 5.25-inch, internal Winchester disk drives and external 8-inch or 9-inch drives to satisfy their machine's insatiable thirst for memory storage.

However, advances in disk drive technology continue to put increasingly higher amounts of memory on smaller, desktop drives. What this means for manufacturers of small, high-capacity rigid disk drives is broadening opportunities in the workstation arena. "As 5.25-inch drives and half-height drives, continue to increase in capacity, workstation vendors will shift to those drives, from 8-inch and 9-inch product," says Patrick McMahon, general manager of marketing support for Minneapolis-based Control Data Corp.'s storage products group.

Spurring the shift is both storage capabilities and disk drive format. "In the workstation arena, there is no ceiling or limit on the demand for capacity," says Robert Teal, vice president of marketing at Maxtor Corp., a San Jose, California-based maker of high-capacity, 5.25-inch rigid disk drives. Workstation makers, says Teal, want higher resolution color graphics which require more and more data storage capacity. Yet, because workstations are multiuser desktop computers, the machines are, "limited to a footprint the size of a typewriter," says Teal.

> "In the workstation arena, there is no ceiling or limit on the demand for capacity"
>
> Robert Teal of Maxtor

Today, though, the most commonly used workstation drive is an 85 megabyte (MB), 5.25-inch Winchester, says James N. Porter, president of market research firm, Disk/Trend Inc. in Los Altos, Calif.

Most high-capacity disk drive makers offer 85 MB, 5.25-inch drives but the leader, with over 50% of the market, say analysts, is Micropolis Corp., a drive manufacturer in Chatsworth, Calif. About 75% of its sales, says Chester Baffa, vice president of marketing and sales, can be attributed to its 85 MB product, the 1325.

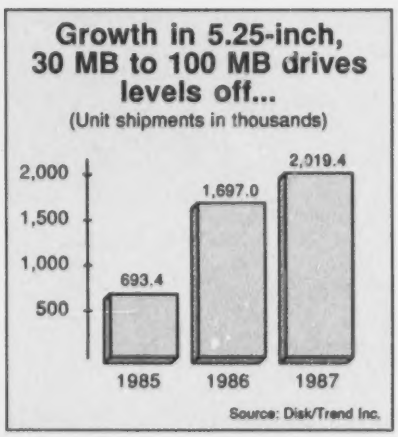
About 60% of Micropolis' business, guesses Baffa, is with workstation vendors. "We have about 10% of the workstation market," estimates Baffa. Few would argue with him. "If you look at who is doing high volume," sales in the workstation arena, says Baffa, you would find the names on Micropolis' customer list.

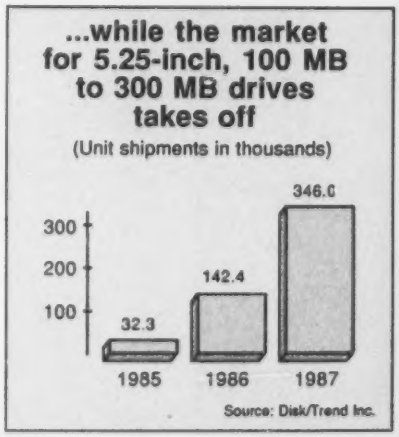
Apollo, Digital Equipment Corp., MASSCOMP and Sun all buy drives from Micropolis. DEC, which buys Micropolis drives for a number of systems, including the MicroVax II, represented nearly half of Micropolis' 1986 first quarter $50 million sales. Analysts lament that Micropolis is dangerously dependent upon DEC, which also buys drives from Maxtor. But Baffa says that Micropolis' percentage of DEC sales will drop to the "high teens " by year-end. Says Baffa: "That's not terribly uncomfortable."

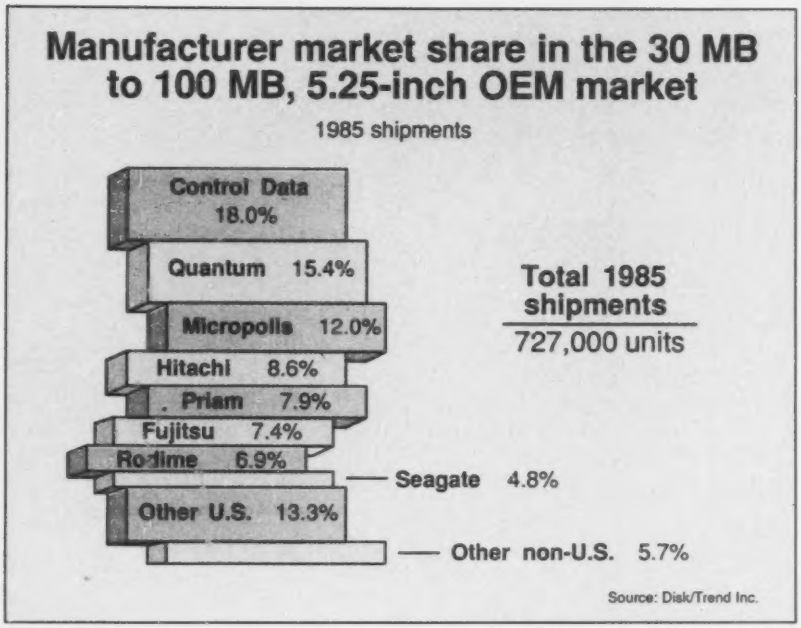
Another 15% of Micropolis' sales are from its 170 MB, 5.25-inch drive. Disk/Trend's Porter expects that 85 MB drives will soon be replaced by 170 MB as the staple product for workstation vendors. In the 100 MB to 300 MB market, says Porter, Maxtor has garnered 19.2% of the worldwide market, second to Fujitsu's leading 26.9% share.

Although Maxtor offers an 85 MB drive, says Teal, the company concentrates on the high-end with the majority of their volume sales in the 100 MB to 300 MB range. Maxtor's original equipment manufacturer (OEM) deals include workstation makers Apollo, General Electric's Calma Co., DEC and Intergraph Corp. "The combination of workstations and graphics is our fastest growing segment," says Teal. One-third of Maxtor's $85.2 million in 1986 revenue, estimates Teal, was from workstation vendors.

Other industry observers, like John







Hagerman, director of product marketing at Priam Corp., a disk drive manufacturer in San Jose, believe that workstation makers may bypass 170 MB drives and start using 382 MB drives as their cornerstone offering. Maxtor's Teal thinks 5.25-inch Winchester drives can eventually be pushed to 2 gigabytes of storage. Other manufacturers are skeptical but Maxtor has already announced a 760 MB, 5.25-inch drive. Available in volume shipments in March, Maxtor's XT-8000E will be the highest capacity, 5.25-inch drive on the market.

A formal controversy

In addition to the controversy over storage capacity limitations, disk drive manufacturers argue over which form factor will rein supreme. CDC's McMahon, for example, believes that workstation makers will move toward the half-height, 5.25-inch product because it shrinks the size of the drive while retaining high capacity. Maxtor's Teal believes that half-height products will not have a chance to mature before 3.5-inch drives attain high enough capacities to attract vendors. The highest capacity for 3.5-inch drives available today, says Teal, is a 40 MB drive. But by the third quarter of 1987, Maxtor expects to announce a 3.5-inch drive in excess of 100 MB.

Others see potential in nascent optical storage technology. Peter Lloyd, president of Optimem, a Sunnyvale, California-based maker of 12-inch optical drives, says that he has, "talked to the majority of well-known workstation makers." Their initial interest, says Lloyd, is in current, write-once product for archival storage. He expects Optimem's next generation product — a 5.25-inch drive with erasable media — to garner "a large segment of business," in the workstation market. Lloyd says that Optimem will announce that product in the beginning of 1987 and volume production will be available by year-end.

But Micropolis' Baffa is wary of it all. "The trend in that business [workstations] is clearly not toward 3.5-inch or optical," says Baffa. "Three and a half-inch is not going to be able to support the kind of storage they need for a long time," explains Baffa. And optical storage, he says, is far too slow to be considered viable.

Who buys from whom

Workstation manufacturer	Disk drive sources
Apollo	CDC, Maxtor, Micropolis, Priam
DEC	Maxtor, Micropolis
Hewlett-Packard	Internal, Priam
IBM (for RT PC)	Internal
MassComp	Fujitsu, Micropolis, NEC
Silicon Graphics	Fujitsu, Hitachi, Priam, Tandon
Sun Microsystems	Fujitsu, Micropolis

Source: Workstation and disk drive manufacturers

Then there are diskless workstations offered by workstation makers such as Apollo and Sun. The idea, says Vicki Brown, a workstation analyst with International Data Corp. in Framingham, Mass., is to lower the cost per workstation. Diskless workstations access memory headquartered at a central server. Access time is slower, concedes Brown, but it allows manufacturers to offer systems below $10,000.

But most drive manufacturers do not believe diskless workstations will become pervasive enough to have an impact on their business. Priam's Hagerman contends that bandwidth limitations on the bus between server and workstation slow the process down too much. David Vellante, a disk drive analyst with IDC, says that networking software required for diskless nodes could negate any cost savings that the system offers.

A standard controversy

The interface standard problem is another evolving factor in the disk drive market today. Three standards, say observers, are emerging in the high-capacity, 5.25-inch rigid disk drive market. The first, the ST-412, is an IBM interface standard that is used on approximately 90% of all drives shipped, estimates Priam's Hagerman. But the ST-412, says Maxtor's Teal, has a bottleneck that slows transfer rates.

The two remaining drive interfaces used today — the Enhanced Small Device Interface (ESDI) and Small Computer Systems Standard (SCSI) — share the remaining 10% of shipments. Both are faster than the dominant ST-412 standard. The primary difference between the two, says IDC's Vellante, is that SCSI drives have embedded controllers and ESDI drives do not. The SCSI interface allows for off-the-shelf products that are quicker to market. But some systems vendors, says Vellante, want to design their own controllers that can be put into ESDI drives. Priam's Hagerman anticipates vendors shifting toward both ESDI and SCSI, and away from ST-412.

Also gaining momentum in the disk drive market are Japanese vendors. While Fujitsu and Hitachi have both been dominant in the worldwide disk drive market, they have not, until re-

Your Business Will Soar In Our Atmosphere.

On most clear days in the highlands of Bristol, all you have to do is look to the sky to see a Redtail hawk—the symbol of our city—soaring in a majestic spiral overhead.

We chose the Redtail to stand for the independent spirit, pride and natural beauty that are so much a part of life in this great location.

Maybe you didn't know this, but the Virginia-Tennessee state line runs right down the middle of town. And when you're downtown in Bristol, you're only a day away from half the resources in America, and you're not that far from Canada.

The atmosphere of friendliness and room to grow are why some of the most successful companies in the country like Raytheon, Electrolux, and Sperry have landed in the Bristol area, recently rated as one of the top places to live by *American Demographics Magazine.*

One more thing about those Redtail hawks. There are some nesting right now near our new industrial park. Maybe you'll see one for yourself when you come to visit.

If your business is on the way up,
send in this coupon for a bird's eye view of Bristol.

Name_____

Company_____ Title_____

Type of business_____

Address_____

City_____

State_____ Zip_____

Telephone(___)_____

Bristol 1st
P.O. Box 519
Bristol, TN-VA 24203-0519
615/968-4399

BRISTOL
Your Business Will Soar In Our Atmosphere.

cently, been a force in the U.S. market. "The Japanese came over here with different standards," says IDC's Vellante, which were incompatible with existing systems. The Japanese manufacturers are just beginning to develop product here, says Vellante, and when the supermicrocomputer takes off in Japan, he believes that Japanese disk drive makers may find greater success here in the States.

So far, though, Fujitsu has found some popularity through its Eagle drive, a 10.5-inch, 474 MB drive reportedly used by Sun. MASSCOMP

The interface standard problem is another evolving factor in the disk drive market

also buys drives from both Fujitsu and NEC Corp. And Silicon Graphics purchases drives from Fujitsu and Hitachi.

And then there is always the workstation manufacturers themselves. Most are too small to consider manufacturing disk drives, which are "not easy and not cheap to make," says IDC's Vellante. But because disk drives can also be the most costly component added onto a system, there is incentive for large manufacturers to make their own.

This, of course, could have a significant impact on high-capacity, drive manufacturers that universally depend on high-volume OEM sales. IBM already manufactures all of its drives used on its engineering workstation, the RT PC. Hewlett-Packard Co., which buys some 5.25-inch 24 MB and 55 MB drives from Priam, makes its own high-capacity, and higher margin, drives. And DEC, which does not make any 5.25-inch drives, is rumored to be developing 5.25-inch for in-house production.

For both Maxtor and Micropolis that could mean trouble. But Micropolis' Baffa, who ranks DEC as the company's biggest customer, would not be the least surprised by such a decision. He claims no knowledge of DEC's intentions, but says, "DEC will absolutely manufacture its own [5.25-inch] disk drives." If DEC is serious about drive manufacturing, says Baffa, it will have to go to 5.25-inch. "Higher dimensions won't be where the world will be," says Baffa. "My perception is that it's a logical business decision for them." □

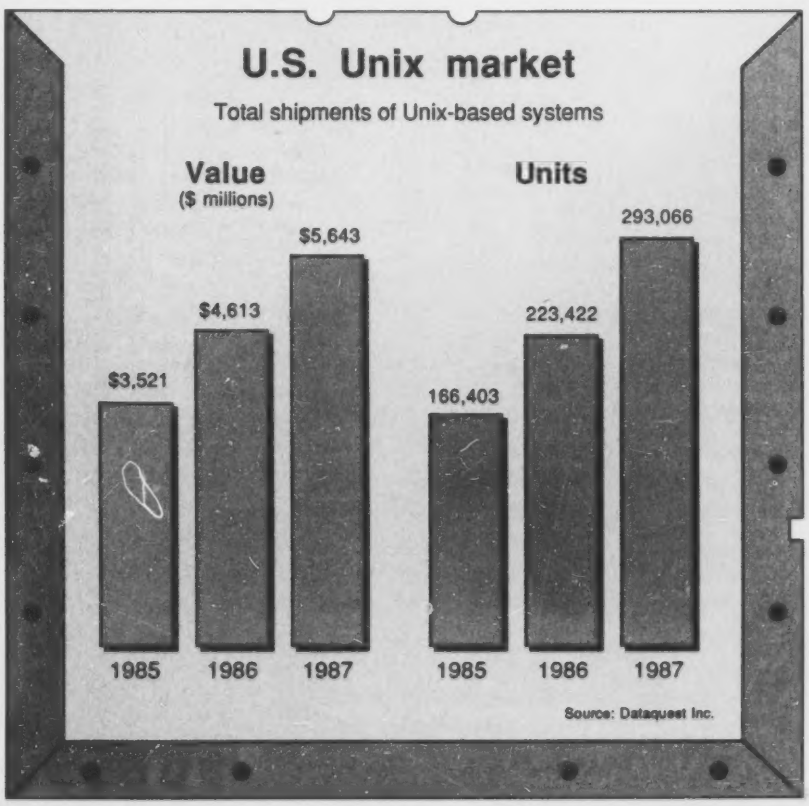
Unix: Portable software for a stable market

After several false starts, Unix is now the operating system of choice for numerous U.S. computer manufacturers

By Anne Knowles

Unix — the operating system developed by AT&T Bell Laboratories — has been long in coming. Ever since AT&T began licensing it to commercial manufacturers in 1973, industry watchers have predicted Unix would become a *de facto* standard in software used to control the internal functions of a computer. A portable operating system that can be adapted to different size systems from different makers, Unix was labeled the answer to an end-user's dream.

But every year the market for Unix-based systems has been about half what analysts projected. Today, though, the forces necessary to drive the Unix market are gaining momentum. Customers with clout — like General Motors Corp. (GM) and the U.S. government — demand it. And major manufacturers — like Digital Equipment Corp. (DEC) and IBM — sell it.



THE MARKET

Until recently, Unix was not an ideal operating system for commercial applications. It is a difficult operating system for the nontechnical user due to what many call its "cryptic commands," — the puzzling instructions a user needs to follow in order to use Unix. It suffers from a lack of application packages. Paul Cubbage, an analyst with Dataquest Inc., in San Jose, Calif., estimates that there are between 500 and 1,000 Unix application packages but among those there are only 100 to 200 different types.

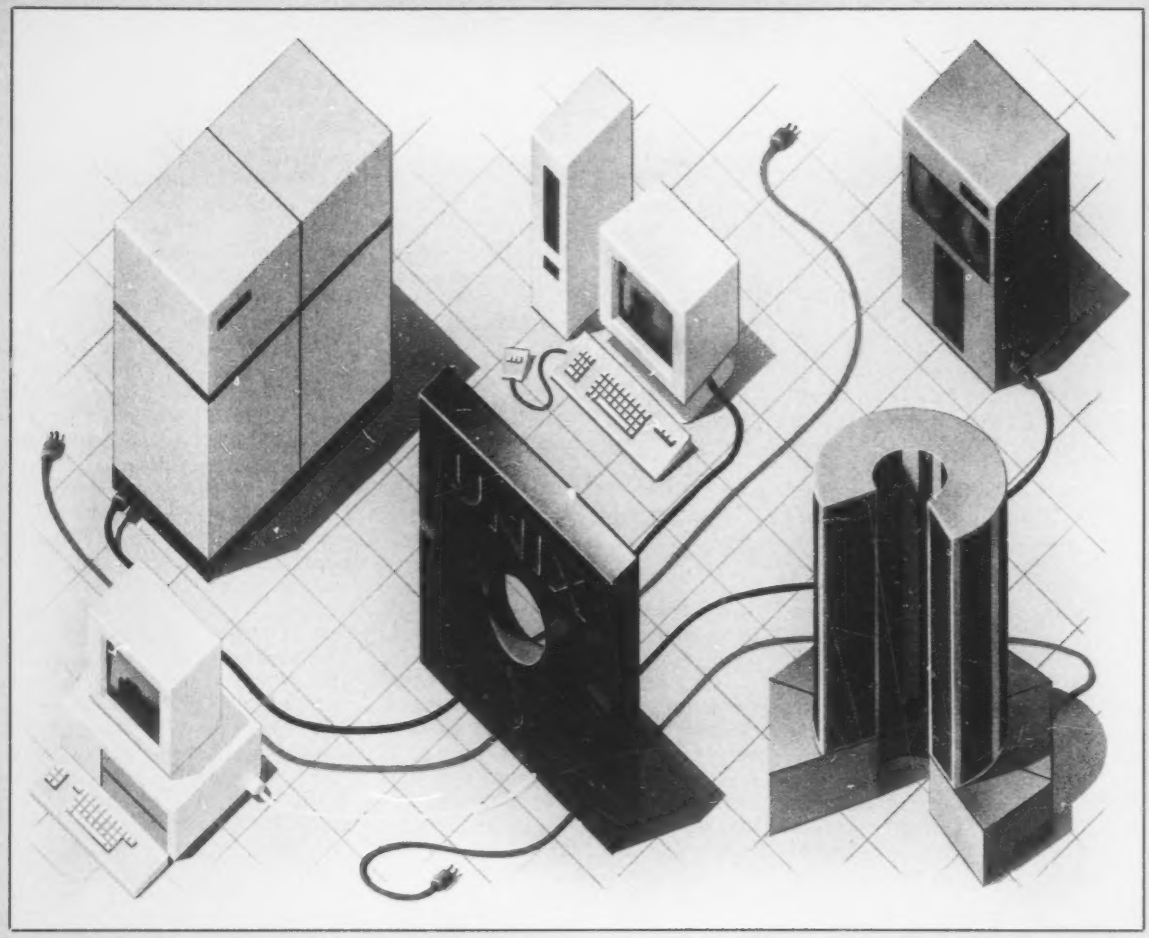
And Unix, as licensed from AT&T, did not have key security features necessary for commercial purposes until AT&T introduced its second rewrite of System V. And until AT&T brought out its latest version this summer, christened Release 3, Unix was not equipped for networking.

Ironically, though, Unix was first sold by supermicrocomputer manufacturers targetting commercial markets. When 16-bit microprocessors became available and start-ups like Altos Computer Systems, Fortune and Plexus Computers Inc. began marketing systems based on them, Unix was their operating system of choice. And the commercial arena was their market of choice.

"CP/M [a single-user operating system used extensively on 8-bit computers] was not appropriate for multiuser systems," says Robert Marsh, chairman and founder of Plexus, which negotiated the first distribution license for Unix with AT&T. "We were familiar with Unix and AT&T made it available on terms we could tolerate."

Altos experienced the same process. "We were selling systems with MP/M

(Continued)



Setting the standard

Creating a cohesive, coherent network of computers is not an easy task. Many blame the current slump in the computer industry on that very fact. While Unix does not provide the answer to the problem, some say it could be part of the solution.

Operating systems are programs that control the operations of a computer. Many of them are written in machine language which is specific to each computer. They are optimized to run on that hardware and they are difficult to transport to other, different types of hardware.

Unix, on the other hand, is a portable operating system. Most of it was written in the programming language C, developed for Unix. Companies license the operating system's source code — the statements written in programming language — from AT&T. The operating system can then be adapted to any computer by using a software compiler which translates Unix's source code into that computer's unique machine language.

The variety of systems running versions of Unix bears witness to the operating system's portability. Cray Research Inc. uses it on its Cray 2 supercomputer while IBM runs a version of Unix developed by Interactive Systems Corp., called AIX, on its RT PC engineering workstation and Xenix, from Microsoft, on its PC AT. Digital Equipment Corp. offers Ultrix, its Unix-like system, on its family of VAX superminicomputers and Amdahl Corp., in 1981, was the first vendor to port Unix (its version is called UTS) to a mainframe.

Software written for Unix is also portable. Ideally, any Unix software application package should be able to run on any Unix-based machine.

Unix is also a good operating system for software development, originally developed by Bell Laboratories in 1969 for that purpose. It is supported by a set of software tools that encourages development of application packages for it. And AT&T began licensing the operating system, for an affordable fee, to universities in the early 1970s. Unix became firmly entrenched in university computer labs and created a large pool of trained and loyal programmers.

In fact, Unix owes much of its popularity to its roots in academia. Its primary contribution is as a standard for the industry. Certain features incorporated in Unix are by no means unique to it. Multitasking — the ability to perform more than one job at at a time — and software development tools can be found on many operating systems. "Unix has an edge up because it was used in education. People left there and went into industry," says Jeffrey Bork, director of systems marketing at Altos Computer Systems.

Marty Braun

[a CP/M-like operating system]," says Jeffrey Bork, director of systems marketing at Altos. So Altos chose Unix. Both Altos and Plexus added enhancements to the system, including file locking for security and networking features, that made the offerings more attractive to commercial users. Commercial customers, says Altos' Bork, have always been "our bread and butter."

The majority of Plexus' sales, says Plexus' Marsh, go into data processing applications. But the U.S. government has always represented a substantial portion, about 20%, of Plexus' business.

Plexus is not the only Unix vendor doing business with the U.S. government. In search of a standard operating system, the U.S. government settled on Unix and now approximately 75% of all government requests for proposals stipulate Unix. AT&T alone has contracts with three federal agencies — Department of Agriculture, National Security Agency and U.S. Customs — for the company's 3B Unix-based systems valued at over $1.1 billion.

There is also considerable interest overseas by foreign computer manufacturers who, lacking software of their own, see Unix as a way into the American market. But for the moment, at least, it is still big name U.S. customers that have driven the market for Unix-based systems. AT&T and the Bell Operating Companies provided the impetus Digital Equipment Corp. needed to develop its Unix-like operating system called Ultrix. Before AT&T's divestiture it was DEC's biggest customer. AT&T wanted Unix and encouraged DEC to offer it, says Nils Noren, DEC's marketing manager for Ultrix. Despite the fact that AT&T has shifted to buying its own equipment since divestiture, and is no longer DEC's largest customer, about 22% of DEC's VAX computers are sold with Ultrix, estimates Dataquest's Cubbage.

Foreign computer manufacturers see Unix as a way into the American market

And now General Motors has also decreed that its factory floor is now a Unix shop. Even though Unix was not developed as a real-time operating system, GM wanted to standardize on an operating system that would enable the automaker to transport software across different vendors' hardware, says John Williams, senior manufacturing product engineer for advanced manufacturing at Chevrolet, Pontiac, GM of Canada. "It has been adopted as a strategic goal. Manufacturers don't absolutely have to have Unix," when bidding for contracts, says Williams. "But [contract awards] will be Unix unless a vendor can prove reason otherwise."

Unix's greatest success, however, has been in the scientific, engineering and education markets. The reasons for that are varied. Part of the reason is that AT&T licensed Unix to universities for a nominal fee. Unix developed a loyal following within the education field and the programmers and engineers entering the job market were trained on it.

Systems that are used almost exclusively for technical applications — supercomputers and minisupercomputers — often use Unix. Cray Research Inc. of Minneapolis, which has about 70% of the worldwide supercomputer market, added Unix on its Cray 2 supercomputer despite the fact that its propietary system, COS (Cray Operating Systems), dominates the market. And the relatively young minisupercomputer manufacturers chose to develop systems based on Unix rather than risk acceptance of yet another proprietary operating system. The one exception, Scientific Computer Systems Corp., uses an operating system compatible to Cray's proprietary COS.

Another relatively young market — computer aided engineering and design (CAE, CAD) — is moving toward Unix. Some of the players — Intergraph Corp., Sun Microsystems Inc. and Valid Logic Systems Inc. — always used Unix and others — Apollo Computer Inc., Daisy Systems Corp. and Mentor Graphics Corp. — who started out on proprietary operating systems have converted to Unix. And IBM's late entrant into the market, the RT PC, runs AIX, a Unix-like operating system developed by Inter-

U.S. Unix market — dollar value

Shipments of Unix-based systems ($ millions)

	1985	1986	1987
Mainframes	$241	$303	$393
Business unit (64-128 users)	142	199	240
Large department (32-64 users)	172	264	335
Small department (20-32 users)	213	297	357
Work group (2-10 users)	2,138	2,552	3,050
Single-user workstation	517	836	1,044
Personal computer	98	162	224

U.S. Unix market — unit shipments

Shipments of Unix-based systems (units)

	1985	1986	1987
Mainframes	71	89	114
Business unit (64-128 users)	282	423	564
Large department (32-64 users)	844	1,303	1,700
Small department (20-32 users)	4,347	6,224	7,689
Work group (2-10 users)	118,448	142,075	178,791
Single-user workstation	15,674	27,324	40,170
Personal computer	26,737	45,984	64,038

Source: Dataquest Inc.

PLEXUS' MARSH: Negotiated the first distribution license for Unix with AT&T

active Systems Corp., in Santa Monica, Calif. "In workstations, Unix is where it is at," says James Groff, president of Network Innovations Corp., a developer of networking software in Cupertino, Calif.

COST OF ENTRY

Because Unix was designed to be free of hardware dependency, it is relatively easy to get up and running on any computer. Unix is written in the programming language C which was developed in conjunction with the operating system. Both are machine independent, meaning they do not rely on specific hardware for their functions.

AT&T licenses the Unix source code, the instructions written in C programming language, to hardware manufacturers. For Unix System V, Release 3, AT&T's latest version of Unix, it costs $65,000 for the first central processing unit. If a vendor wants to adapt, or "port" Unix to a second system, the next license costs $20,000. Every CPU or computer model after that can be sublicensed for $2,000 each. The prices are set and initial costs remain stable.

Network Innovations' Groff estimates it requires two engineers about three months to port Unix to a computer. "All you have to do is get a C compiler," which translates Unix into a specific computer's machine language, says Groff. In contrast, most other operating systems, says Groff, are written in low-level machine language. To transport them to another computer with different machine language requires rewriting of the source code.

DEC ported Unix 4.2 BSD, a version of Unix developed at University of California at Berkeley, to its VAX architecture, which runs DEC's proprietary operating system, VMS. "There was a lot of bug fixing," says DEC's Noren. "But there really wasn't much to do because Unix has always run on VAX [computers]." Unix was developed at AT&T on DEC's PDP-11 minicomputers.

> AT&T has also been working closely with semiconductor manufacturers to put Unix on off-the-shelf processors

AT&T has also been working closely with semiconductor manufacturers to put Unix on off-the-shelf processors. Intel Corp.'s 80X86 series of processors now run Unix, including Release 3 which is being ported to Intel's 80386 32-bit chip. Unix has also been ported to Motorola's 68000 family and National Semiconductor Corp.'s 32000 series.

The long list of established vendors who have added Unix to their systems, says Groff, "is proof in the pudding," to Unix transportability. But that does not say Unix is a *fait accompli* on any system. IBM's mid-range System 36, for example, is "an anti-Unix machine," says Dataquest's Cubbage.

THE COMPETITION

AT&T has granted about 2,000 Unix licenses. That includes licenses to educational institutions, hardware vendors and end users. David Sandell, AT&T's director of technical sales support for Unix, estimates Unix is running on "well over 100 machines."

The adoption of Unix by major manufacturers has altered the competition. Plexus' Marsh says the company decided on Unix assuming the market for the systems would remain a niche. Because of that, projected Marsh, the players would be small. "I am sort of overwhelmed by the speed with which all major manufacturers have implemented Unix," says Marsh. "If I had known that," adds Marsh, "I might not have done it at all or I would have stuck to the low end."

Most manufacturers add enhancements to their flavor of Unix in order to differentiate their offerings. Barebones Unix lacks certain capabilities, which a vendor can develop, that preclude it from certain markets. Charles River Data Systems Inc. of Framingham, Mass., for example, has added real-time capabilities to its version of Unix. Altos developed Worknet, a networking enhancement similiar to AT&T's Remote File Sharing, incorporated into its Release 3. Plexus markets its Unix-based system for distributed processing. Honeywell Inc. developed a "user-friendly," menu-driven shell, called Easylife, for its new Unix-based multiuser systems.

DEC gave Ultrix DECnet communications systems support, added software tools and utilities and documentation, including a catalogue of over 100 third-party software application packages. Vendors can also speed up Unix, says DEC's Noren, by adding assembly (or machine) language to the program which customizes Unix to their machines. But, warns Noren, manufacturers have to be careful not to tamper too much with the operating system. Vendors "can add some value," says Noren. "But they can't put on bells and whistles that won't

Tim Davis

run in other environments."

Unix-based systems are also wrestling other operating systems for market share. While Unix is sold on single-user workstations and personal computers, application packages for PC-DOS, IBM's PC operating system, are growing at a faster rate than Unix packages, says Bonnie Digrius, an analyst with Input, a market research firm in Mountain View, Calif. But beyond single-user systems PC-DOS cannot rival Unix because it is not a multiuser system.

IBM's MVS controls the mainframe segment by sheer force of numbers: IBM has an estimated 76% share of that market. And the midrange — minicomputers and superminicomputers — scientific and engineering arena is dominated by DEC's VMS.

The commercial market for departmental systems, though, — again minis and superminis — is still fragmented, says Network Innovations' Groff, between DEC's VMS, the SSP operating system on IBM's System 36, Unix and a handful of other proprietary systems. It is in that area, says Groff, that Unix is "certainly not a foregone conclusion."

Dataquest's Cubbage thinks that Unix will never wrest control of those markets already established by other operating systems. "By the end of the decade," says Cubbage, "the operating systems that have infrastructures today — MVS, VMS, MS-DOS and Unix — will survive."

THE OBSTACLES

Unix has always been surrounded by controversy. Customers complain it is difficult to use. Manufacturers maintain it is inferior to their own, proprietary operating systems. But Unix has evolved and certain problems have been resolved.

Many technical problems for the commercial user were finally addressed when AT&T announced its second version of System V, called Release 2. Until then, Unix did not have key security features necessary for commercial environments. But Release 2 provided file and record locking, enabling the user to protect files from being tampered with by another user. And in Release 3 AT&T added two networking enhancements: Streams provides a hardware independent protocol for networking Unix-based systems and remote file sharing enables two Unix-based computers to share files and peripherals.

Other technical glitches continue to vex users. Unix is not easy to use for the end user; the instructions, or commands, a user has to give are puzzling. Unix also requires a lot of memory and on mainframes and minicomputers, where it needs two to six megabytes of memory, that can be expensive. But any system has its drawbacks and the issue of Unix's "cryptic commands," says Network Innovations' Groff, "is a red herring." In other words, such complaints are only a distraction from the real issue.

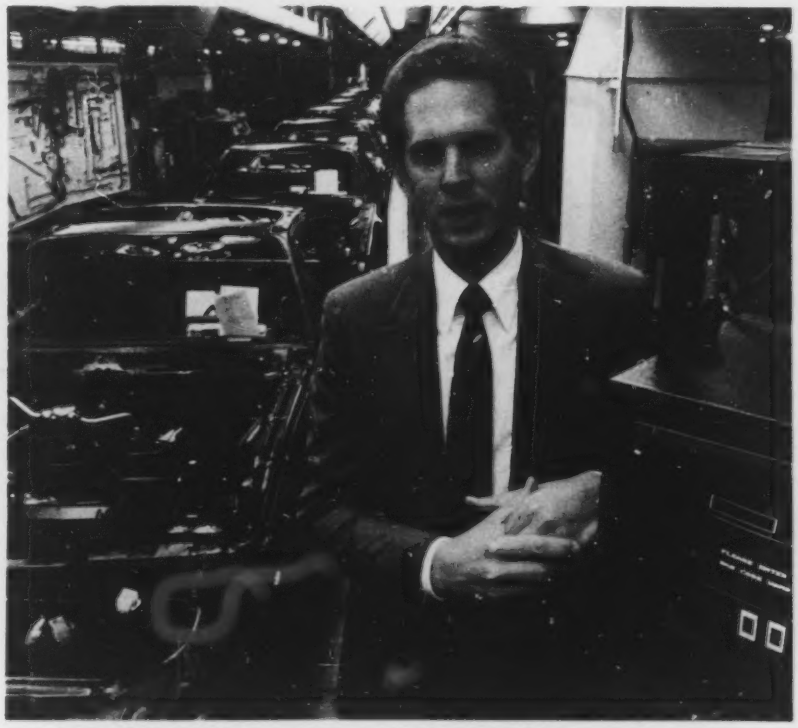
"The barriers are psychological, not technical," says Groff. For several years, Unix did not live up to the phenomenal growth forecasts projected by market researchers. In 1984, for example, actual shipments of Unix-based supermicrocomputers trailed 57% behind estimates, according to Frost & Sullivan Inc., a market research firm in New York City.

Another hurdle is the lack of Unix leadership in the industry. "AT&T hasn't been successful in marketing Unix-based minis," says Network Innovations' Groff. And while Unix found acceptance in technical markets, says Groff, "AT&T was dragging its feet on putting in commercial enhancements."

In addition, established manufacturers, who have tied their installed base to a proprietary operating system, have been reluctant to promote Unix. "They're [IBM and DEC] making the efforts [to provide Unix]," says James Meadlock, president of Intergraph Corp. in Huntsville, Ala., "but both of them would really like to see it die. Theirs is a totally defensive effort." Continues Meadlock: "The guys who really want Unix to succeed are the end users who want to believe they are buying a solution that doesn't tie them to one company."

"If we didn't offer it, somebody else would have," responds DEC's Noren.

But the forces necessary to establish Unix as a standard, says James Isaac, director of strategic marketing at Charles River Data, are in place. The Institute of Electrical and Electronic Engineers (IEEE) has set up a standards committee to establish a Unix standard called POSIX that incorporates features of both AT&T's Unix V and University of California at Berkeley's Unix 4.2 BSD. In April, the IEEE came out with a trial-use standard and by fall of 1987, says Isaac, a full-use standard will be completed. "You need three things to make a standard," explains Isaac. First, users, such as GM and the government, who require it. Second, vendors who have implemented it. And a clear definition, provided by the IEEE, of what it is. □



Junebug Clark

GM's WILLIAMS: Unix has been adopted as a strategic goal

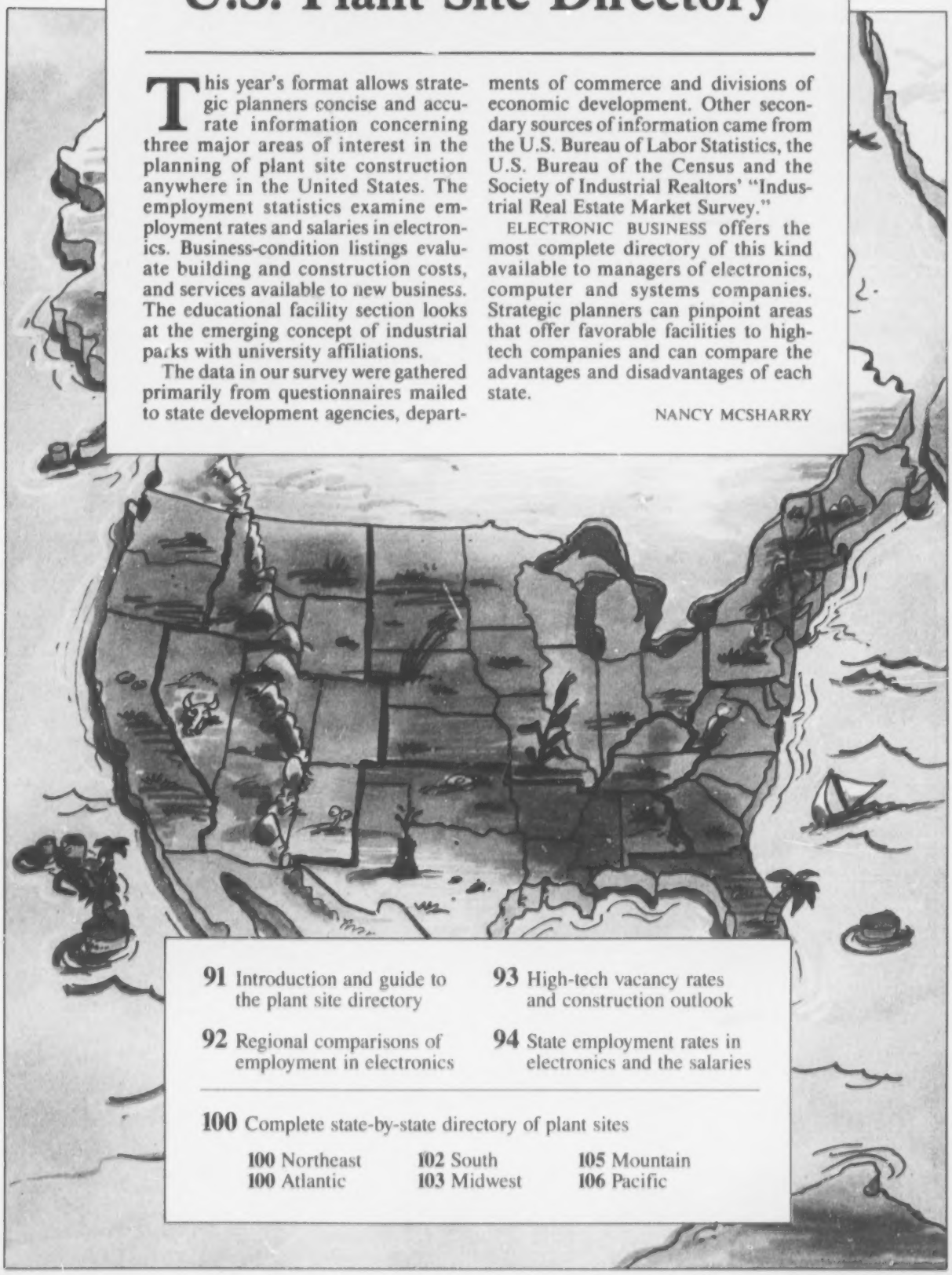
U.S. Plant Site Directory

This year's format allows strategic planners concise and accurate information concerning three major areas of interest in the planning of plant site construction anywhere in the United States. The employment statistics examine employment rates and salaries in electronics. Business-condition listings evaluate building and construction costs, and services available to new business. The educational facility section looks at the emerging concept of industrial parks with university affiliations.

The data in our survey were gathered primarily from questionnaires mailed to state development agencies, departments of commerce and divisions of economic development. Other secondary sources of information came from the U.S. Bureau of Labor Statistics, the U.S. Bureau of the Census and the Society of Industrial Realtors' "Industrial Real Estate Market Survey."

ELECTRONIC BUSINESS offers the most complete directory of this kind available to managers of electronics, computer and systems companies. Strategic planners can pinpoint areas that offer favorable facilities to high-tech companies and can compare the advantages and disadvantages of each state.

NANCY MCSHARRY



91 Introduction and guide to the plant site directory

92 Regional comparisons of employment in electronics

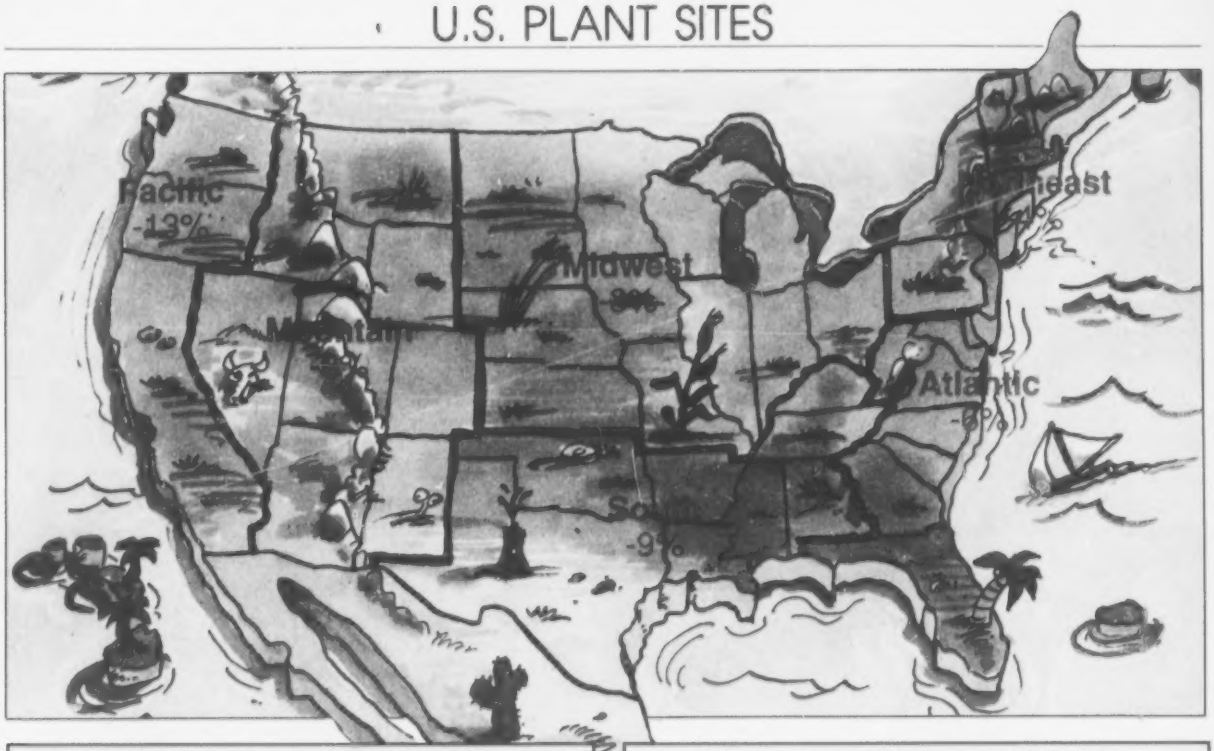
93 High-tech vacancy rates and construction outlook

94 State employment rates in electronics and the salaries

100 Complete state-by-state directory of plant sites

100 Northeast
100 Atlantic
102 South
103 Midwest
105 Mountain
106 Pacific

U.S. PLANT SITES



Total 1985 employment in electronics

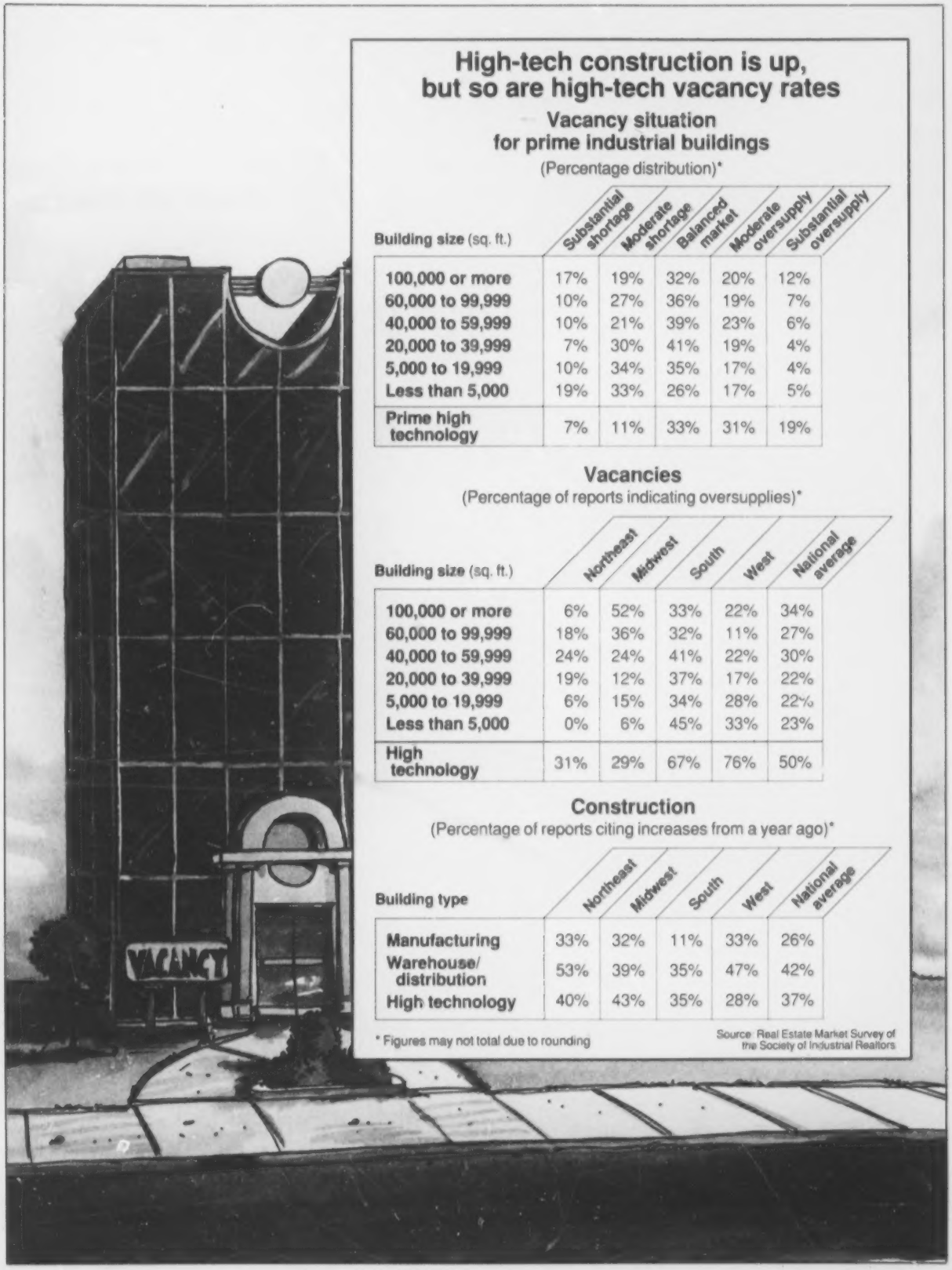
Northeast	
Connecticut	77,500
Maine	N/A
Massachusetts	170,600
New Hampshire	25,800
New Jersey	93,600
New York	279,800
Pennsylvania	151,900
Rhode Island	11,200
Vermont	4,500
Total	**814,900**
Atlantic	
Delaware	1,428
Florida	59,800
Georgia	25,600
Maryland	20,900
North Carolina	57,700
South Carolina	35,100
Virginia	19,700
West Virginia	6,000
Total	**226,228**
South	
Alabama	19,700
Arkansas	16,800
Kentucky	33,700
Louisianna	10,100
Mississippi	14,300
Oklahoma	39,400
Tennessee	46,500
Texas	159,500
Total	**340,000**
Midwest	
Illinois	184,600
Indiana	77,500
Iowa	42,600
Kansas	10,400
Michigan	145,900
Minnesota	89,900
Missouri	43,200
Nebraska	10,600
North Dakota	N/A
Ohio	189,200
South Dakota	1,007
Wisconsin	111,500
Total	**906,407**
Mountain	
Arizona	41,481
Colorado	25,400
Idaho	6,000
Montana	N/A
Nevada	N/A
New Mexico	2,800
Utah	15,500
Wyoming	N/A
Total	**91,181**
Pacific	
Alaska	N/A
California	344,400
Hawaii	N/A
Oregon	30,200
Washington	27,600
Total	**402,200**

Source: U.S. Department of Labor, Bureau of Labor Statistics

Percentage change – 1985/1986

Northeast	
Connecticut	-5%
Maine	N/A
Massachusetts	+3%
New Hampshire	-1%
New Jersey	-6%
New York	-6%
Pennsylvania	-6%
Rhode Island	+2%
Vermont	-7%
Average	-4%
Atlantic	
Delaware	N/A
Florida	-1%
Georgia	-1%
Maryland	-11%
North Carolina	-5%
South Carolina	-3%
Virginia	-2%
West Virginia	-6%
Average	-6%
South	
Alabama	+2%
Arkansas	-1%
Kentucky	-7%
Louisianna	-13%
Mississippi	-6%
Oklahoma	-12%
Tennessee	-4%
Texas	-12%
Average	-9%
Midwest	
Illinois	-3%
Indiana	+8%
Iowa	-5%
Kansas	N/A
Michigan	-2%
Minnesota	-10%
Missouri	-2%
Nebraska	-13%
North Dakota	N/A
Ohio	-5%
South Dakota	N/A
Wisconsin	+1%
Average	-3%
Mountain	
Arizona	N/A
Colorado	-2%
Idaho	-10%
Montana	N/A
Nevada	N/A
New Mexico	-11%
Utah	N/A
Wyoming	N/A
Average	-8%
Pacific	
Alaska	N/A
California	-14%
Hawaii	N/A
Oregon	-6%
Washington	+1%
Average	-13%

Change is between the first eight months of each year



High-tech construction is up, but so are high-tech vacancy rates

Vacancy situation for prime industrial buildings

(Percentage distribution)*

Building size (sq. ft.)	Substantial shortage	Moderate shortage	Balanced market	Moderate oversupply	Substantial oversupply
100,000 or more	17%	19%	32%	20%	12%
60,000 to 99,999	10%	27%	36%	19%	7%
40,000 to 59,999	10%	21%	39%	23%	6%
20,000 to 39,999	7%	30%	41%	19%	4%
5,000 to 19,999	10%	34%	35%	17%	4%
Less than 5,000	19%	33%	26%	17%	5%
Prime high technology	7%	11%	33%	31%	19%

Vacancies

(Percentage of reports indicating oversupplies)*

Building size (sq. ft.)	Northeast	Midwest	South	West	National average
100,000 or more	6%	52%	33%	22%	34%
60,000 to 99,999	18%	36%	32%	11%	27%
40,000 to 59,999	24%	24%	41%	22%	30%
20,000 to 39,999	19%	12%	37%	17%	22%
5,000 to 19,999	6%	15%	34%	28%	22%
Less than 5,000	0%	6%	45%	33%	23%
High technology	31%	29%	67%	76%	50%

Construction

(Percentage of reports citing increases from a year ago)*

Building type	Northeast	Midwest	South	West	National average
Manufacturing	33%	32%	11%	33%	26%
Warehouse/ distribution	53%	39%	35%	47%	42%
High technology	40%	43%	35%	28%	37%

* Figures may not total due to rounding

Source: Real Estate Market Survey of the Society of Industrial Realtors

Northeast	Population	Total civilian workforce	Total employment in electronics	Average annual salary per employee in total workforce	Average annual salary per employee in electronics	Percentage of workforce unemployed	Percentage of workforce unionized
Connecticut	2,470,000	1,711,000	N/A	N/A	N/A	4.9%	N/A
Maine	874,000	552,000	N/A	N/A	N/A	5.4%	N/A
Massachusetts	4,549,000	3,061,000	340,100	$19,635	$21,688	3.9%	N/A
New Hampshire	756,000	537,000	24,500	$18,075	$20,654	3.9%	15.0%
New Jersey	5,891,000	3,853,000	86,732	N/A	N/A	5.7%	19.0%
New York	13,681,000	8,308,000	156,500	$25,900	$25,900	6.5%	38.7%
Pennsylvania	9,192,000	5,519,000	36,153	$18,434	$24,342	8.0%	41.1%
Rhode Island	748,000	500,000	12,100	N/A	N/A	4.9%	12.0%
Vermont	401,000	277,000	13,300	$15,800	$28,500	4.8%	18.0%

Atlantic	Population	Total civilian workforce	Total employment in electronics	Average annual salary per employee in total workforce	Average annual salary per employee in electronics	Percentage of workforce unemployed	Percentage of workforce unionized
Delaware	469,000	315,000	1,428	N/A	N/A	5.3%	14.2%
Florida	8,903,000	5,338,000	59,800	$17,682	$25,125	6.0%	9.6%
Georgia	4,344,000	2,865,000	25,600	N/A	N/A	6.5%	N/A
Maryland	3,330,000	2,253,000	20,900	N/A	N/A	4.6%	18.6%
North Carolina	4,653,000	3,206,000	57,700	$16,000	$21,300	5.4%	4.8%
South Carolina	2,431,000	1,563,000	35,100	N/A	N/A	6.8%	N/A
Virginia	4,233,000	2,872,000	19,700	N/A	N/A	5.6%	N/A
West Virginia	1,465,000	765,000	6,000	$17,995	$23,581	13.0%	34.4%

Midwest	Population	Total civilian workforce	Total employment in electronics	Average annual salary per employee in total workforce	Average annual salary per employee in electronics	Percentage of workforce unemployed	Percentage of workforce unionized
Illinois	8,644,000	5,673,000	118,303	$18,657	$20,764	9.0%	31.0%
Indiana	4,101,000	2,735,000	86,200	N/A	$24,224	7.9%	N/A
Iowa	2,154,000	1,416,000	N/A	N/A	N/A	8.0%	N/A
Kansas	1,804,000	1,244,000	10,400	$17,333	$16,840	5.0%	10.0%
Michigan	6,794,000	4,352,000	35,800	N/A	$22,090	9.9%	33.0%
Minnesota	3,137,000	2,234,000	N/A	N/A	N/A	6.0%	N/A
Missouri	3,788,000	2,472,000	51,500	$20,789	$20,064	6.4%	18.5%
Nebraska	1,182,000	813,000	9,415	$18,923	$19,034	5.5%	18.2%
North Dakota	489,000	336,000	N/A	N/A	N/A	5.9%	N/A
Ohio	8,065,000	5,130,000	N/A	N/A	N/A	8.9%	N/A
South Dakota	510,000	347,000	1,007	$13,532	$11,000	5.1%	3.5%
Wisconsin	3,574,000	2,374,000	49,300	$22,152	$21,684	7.2%	28.0%

South	Population	Total civilian workforce	Total employment in electronics	Average annual salary per employee in total workforce	Average annual salary per employee in electronics	Percentage of workforce unemployed	Percentage of workforce unionized
Alabama	2,972,000	1,803,000	N/A	N/A	N/A	8.9%	N/A
Arkansas	1,746,000	1,051,000	N/A	N/A	N/A	8.7%	N/A
Kentucky	2,744,000	1,695,000	14,500	$16,754	N/A	9.5%	16.0%
Louisiana	3,199,000	1,987,000	7,400	$17,769	$23,821	11.5%	16.0%
Mississippi	1,855,000	1,121,000	1,600	$14,650	$19,700	10.3%	16.0%
Oklahoma	2,419,000	1,573,000	9,700	$20,838	$20,997	7.1%	N/A
Tennessee	3,583,000	2,245,000	38,356	$16,646	$18,921	8.0%	15.8%
Texas	11,718,000	8,053,000	115,200	$20,160	$21,170	7.0%	16.0%

Mountain	Population	Total civilian workforce	Total employment in electronics	Average annual salary per employee in total workforce	Average annual salary per employee in electronics	Percentage of workforce unemployed	Percentage of workforce unionized
Arizona	2,354,000	1,477,000	41,481	$18,335	$25,495	6.5%	N/A
Colorado	2,386,000	1,720,000	N/A	N/A	N/A	5.9%	N/A
Idaho	707,000	471,000	5,600	$17,500	$27,300	7.9%	12.0%
Montana	603,000	405,000	N/A	N/A	N/A	7.7%	N/A
Nevada	709,000	509,000	N/A	N/A	N/A	8.0%	N/A
New Mexico	1,032,000	646,000	4,987	$17,404	$24,188	8.8%	N/A
Utah	1,062,000	730,000	15,500	$16,800	$21,600	5.9%	10.0%
Wyoming	361,000	253,000	N/A	N/A	N/A	7.1%	N/A

Pacific	Population	Total civilian workforce	Total employment in electronics	Average annual salary per employee in total workforce	Average annual salary per employee in electronics	Percentage of workforce unemployed	Percentage of workforce unionized
Alaska	346,000	253,000	N/A	N/A	N/A	9.7%	N/A
California	19,577,000	12,937,000	N/A	N/A	N/A	7.2%	N/A
Hawaii	734,000	481,000	N/A	N/A	N/A	5.6%	N/A
Oregon	2,042,000	1,327,000	33,677	$17,400	$23,774	8.8%	N/A
Washington	3,280,000	2,105,000	N/A	N/A	N/A	8.1%	N/A

Northeast

Connecticut

Additional information

Name: Mark Fineberg

Agency: Connecticut Department of Economic Development

Address: 210 Washington Street, Hartford, Conn. 06106

Phone: (203) 566-5546

Maine

Additional information

Agency: State Development Agency

Address: 193 State Street, Augusta, Maine 04333

Phone: (207) 289-2656

Massachusetts

Business conditions

Average cost of industrial land (per acre) $44,000

Average construction costs (per square foot) $30

Number of state/local sponsored incubator programs 1

State/local start-up assistance available for new business . . . . . Yes

Educational facilities

Number of four-year colleges and universities 110

Additional information

Name: William J. Sugrue

Agency: S.I.T.E. Program, Department of Commerce and Development

Address: Leverett Saltonstall Building, Government Center, 100 Cambridge Street, Boston, Mass. 02202

Phone: (617) 727-3215

New Hampshire

Business conditions

Average cost of industrial land (per acre) $27,500

Average construction costs (per square foot) $30

Number of state/local sponsored incubator programs 1

State/local start-up assistance available for new business . . . . . Yes

Number of electronics companies 194

Educational facilities

Number of four-year colleges and universities 16

Industrial parks with university affiliations:

Industrial park: UNH Technology Park (proposed)

University affiliation: University of New Hampshire-Manchester

Address: The Consulting Center, Horton Social Science Center, UNH Durham, N.H. 03824

Phone: (603) 862-3750

Contact: Dr. James D. Morrison

Additional information

Name: Paul H. Guilderson

Agency: Office of Industrial Development, State of N.H. Department of Resources & Economic Development

Address: Prescott Park, Building Two, 105 Loudon Road, Concord, N.H. 03301

Phone: (603) 271-2591

New Jersey

Business conditions

Percentage of new business started in 1985 in electronics 30%

State/local start-up assistance available for new business . . . . . Yes

Number of electronics companies . . . 1,050

Additional information

Name: Ben Ferrara

Agency: New Jersey Department of Commerce, Division of Economic Development

Address: One West State Street, Trenton, N.J. 08625

Phone: (609) 292-7757

New York

Business conditions

Average construction costs (per square foot) . . . . . $20-$60

Number of state/local sponsored incubator programs 7

State/local start-up assistance available for new business . . . . . Yes

Number of electronics companies . . . 1,472

Additional information

Name: Raymond Paolino

Agency: New York State Department of Commerce

Address: One Commerce Plaza, Albany, N.Y. 12245

Phone: (518) 474-1431

Pennsylvania

Business conditions

Number of state/local sponsored incubator programs 27

Percentage of new business started in 1985 in electronics 3.48%

State/local start-up assistance available for new business . . . . . Yes

Number of electronics companies 269

Additional information

Name: Joy Pooler

Agency: Bureau of Domestic Commerce

Address: Forum Building, Room 453, Harrisburg, Pa. 17120

Phone: (717) 787-6500

Rhode Island

Business conditions

Average cost of industrial land (per acre) $40,000

Average construction costs (per square foot) $35

Number of state/local sponsored incubator programs 1

State/local start-up assistance available for new business . . . . . Yes

Number of electronics companies . . . . . N/A

Additional information

Name: James Hagan

Agency: Rhode Island Department of Economic Development

Address: 7 Jackson Walkway, Providence, R.I. 02903

Phone: (401) 277-2601

Vermont

Business conditions

Average cost of industrial land (per acre) $15,300

Average construction costs (per square foot) $23

State/local start-up assistance available for new business . . . . . Yes

Number of electronics companies 36

Educational facilities

Number of four-year colleges and universities 12

Additional information

Name: Fred Newhall

Agency: Vermont Economic Development Department

Address: 109 State Street, Montpelier, Vt. 05602

Phone: (802) 828-3221

Atlantic

Delaware

Business conditions

Average cost of industrial land (per acre) $20,000

Average construction costs (per square foot) $23

State/local start-up assistance available for new business . . . . . Yes

Number of electronics companies 11

Educational facilities

Number of four-year colleges and universities 6

Industrial parks with university affiliations:

Industrial park: University of Delaware Office/Research Park - Stanton

University affiliation: University of Delaware

Address: Route 4 and Churchman's Road, I-95, Stanton, Del. 19804

Phone: (302) 645-4251

Contact: George Claypoole

Industrial park: University of Delaware Research Park - Lewes

University affiliation: University of Delaware

Address: New Road, Lewes, Del. 19958

Phone: (302) 645-4251

Contact: George Claypoole

Additional information

Name: Louis H. Papineau Jr.

Agency: Delaware Development Office

Address: 99 Kings Highway, P.O. Box 1401, Dover, Del. 19903

Phone: (302) 736-4271

Florida

Business conditions

Average cost of industrial land (per acre) . . . . . $10,000-$48,000

Average construction costs (per square foot) . . . . . $15-$19

Number of state/local sponsored incubator programs 2

Percentage of new business started in 1985 in electronics 18

State/local start-up assistance available for new business . . . . . Yes

Number of electronics companies 465

Educational facilities

Number of four-year colleges and universities 104

Industrial parks with university affiliations:

Industrial park: Biomedical Research and Innovation Center

University affiliation: Florida International University, University of Florida

Address: College of Engineering, Tamiami Campus, Florida International University, Miami, Fla. 33199

Phone: (305) 554-2521

Contact: Gordon Hopkins

Industrial park: Central Florida Research Park

University affiliation: University of Central Florida

Address: 11800 Research Parkway, Orlando, Fla. 32826

Phone: (305) 282-3944

Contact: Patrick Baughn

Industrial park: First Coast Technology Park

University affiliation: University of North Florida

Address: P.O. Box 17074, Jacksonville, Fla. 32216

Phone: (904) 646-2487

Contact: Will Ingram

Industrial park: Florida Atlantic Research and Development Authority

University affiliation: Florida Atlantic University

Address: Academic Affairs, Florida Atlantic University, Boca Raton, Fla. 33431

Phone: (305) 393-3068

Contact: Jeff Tennant

Industrial park: Innovation Park

University affiliation: Florida State University, Florida A&M University

Address: 1673 W. Paul Dirac Drive, Tallahassee, Fla. 32304

Phone: (904) 575-6381

Contact: W.T. Gaupin

Industrial park: Interstate Business Park

University affiliation: Fort Lauderdale University

Address: 8402 Laurel Fair Circle, Suite 100, Tampa, Fla. 33610

Phone: (813) 623-6511

Contact: Jeff Griffith

Industrial park: Progress Center

University affiliation: University of Florida

Address: One Progress Boulevard, Alachua, Fla. 32615

Phone: (904) 462-4040

Contact: Sandra Burgess

Industrial park: Tampa Bay Area Research and Development Park

University affiliation: University of South Florida

Address: Administration Building, Room 280, University of South Florida, 4202 Fowler Avenue, Tampa, Fla. 33620

Phone: (813) 974-2890

Contact: Gen. Jack Hennessey

Industrial park: Tampa Technology Park

University affiliation: University of South Florida

Address: 201 East Kennedy Boulevard, Suite 1539, Tampa, Fla. 33602

Phone: (813) 229-3462

Contact: Dave Tyler

Additional information

Name: Steve Mayberry

Agency: Florida Division of Economic Development

Address: 501 B Collins Building, 107 W. Gaines Street, Tallahassee, Fla. 32301

Phone: (904) 488-6300

Georgia

Additional information

Name: Director

Agency: Industry and Trade Department

Address: 1400 North Omni International, Atlanta, Ga. 30303

Phone: (404) 656-2245

Maryland

Business conditions

Average cost of industrial land (per acre) . . . . . $9,000-$90,000

Average construction costs (per square foot) . . . . . $2-$7

Number of state/local sponsored incubator programs 1

Number of electronics companies . . . 1,100

Educational facilities

Number of four-year colleges and universities 35

Industrial parks with university affiliations:

Industrial park: Maryland Science and Technology Center

University affiliation: University of Maryland

Address: Bowie, Md.

Industrial park: Shady Grove Life Sciences Center

University affiliation: Johns Hopkins University

Address: Rockville, Md.

Additional information

Name: Michael S. Lofton

Agency: Office of Business and Industrial Development, Department of Economic and Community Development

Address: 45 Calvert Street, Annapolis, Md. 21401

Phone: (301) 269-3566

North Carolina

Business conditions

Average construction costs (per square foot) $27

Number of state/local sponsored incubator programs 6

Percentage of new business started in 1985 in electronics 26.9%

State/local start-up assistance available for new business . . . . . Yes

Number of electronics companies 285

Educational facilities

Number of four-year colleges and universities 30

Industrial parks with university affiliations:

Industrial park: Research Triangle Park

University affiliation: Duke University, North Carolina State University, University of North Carolina at Chapel Hill

Address: P.O. Box 12255, Research Triangle Park, N.C. 27709

Phone: (919) 549-8181

Contact: Robert E. Leak

Industrial park: University Research Park in Charlotte

University affiliation: University of North Carolina at Charlotte

Address: 2400 First Union Plaza, Charlotte, N.C.

Phone: (704) 375-6220

Contact: Seddon Goode Jr.

Additional information

Name: Robert Brinkley

Agency: North Carolina Department of Commerce

Address: 430 N. Salisbury Street, Raleigh, N.C. 27611

Phone: (919) 733-4151

South Carolina

Additional information

Name: Ed Burgess

Agency: Research Division, Planning and Research Department

Address: 1301 Gervais Street, Columbia, S.C. 29202

Phone: (803) 758-3351

Virginia

Additional information
Name: Mark Kildress
Agency: Economic Development Department
Address: Washington Building, Richmond, Va. 23219
Phone: (804) 786-6430

West Virginia

Business conditions
Average cost of industrial land (per acre) $20,000
Average construction costs (per square foot) $18
Number of state/local sponsored incubator programs 3
Percentage of new business started in 1985 in electronics 12.5%
State/local start-up assistance available for new business . . . . . Yes
Number of electronics companies. 31

Educational facilities
Industrial parks with university affiliations:
Industrial park: Morgantown Industrial Park
University affiliation: West Virginia University
Address: 1000 Dupont Road, Building 510, Morgantown, W. Va. 26505
Phone: (304) 292-9453
Contact: John R. Snider
Additional information
Name: Lysander L. Dudley Sr.
Agency: Governer's Office of Community and Industrial Development
Address: Capitol Complex, Room M-146, Charleston, W. Va. 25305
Phone: (304) 348-0400

South

Alabama

Additional information
Name: Lynn Carr
Agency: Agriculture and Industry Department
Address: 1445 Federal Drive, Montgomery, Ala. 36109
Phone: (205) 261-2650

Arkansas

Additional information
Name: Cathy Davidson
Agency: State Data Center/Research and Public Service
Address: University of Arkansas, 33rd and University, Little Rock, Ark. 72204
Phone: (501) 371-1973

Kentucky

Business conditions
Average construction costs (per square foot) $20
Number of state/local sponsored incubator programs 2
Percentage of new business started in 1985 in electronics . . . . . N/A
State/local start-up assistance available for new business . . . . . Yes
Number of electronics companies. 55
Educational facilities
Number of four-year colleges and universities. 25
Additional information
Name: Carroll Knicely
Agency: Kentucky Commerce Cabinet
Address: 2400 Capital Plaza Tower, Frankfort, Ky. 40601
Phone: (502) 564-7670

Louisiana

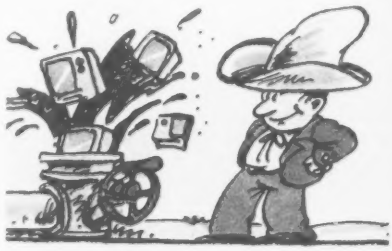
Business conditions
Average construction costs (per square foot) $23
State/local start-up assistance available for new business . . . . . Yes
Number of electronics companies. 91
Educational facilities
Number of four-year colleges and universities. 17
Additional information
Name: Dave Bowman
Agency: Louisiana Department of Commerce
Address: Box 94185, Baton Rouge, La.
Phone: (504) 342-5405

Mississippi

Business conditions
Average construction costs (per square foot) $11
Number of state/local sponsored incubator programs . . . . . None
Percentage of new business started in 1985 in electronics. 4%
State/local start-up assistance available for new business . . . . . Yes
Number of electronics companies. 22
Educational facilities
Number of four-year colleges and universities. 16
Industrial parks with university affiliations:
Industrial park: Mississippi Research and Technology Park
University affiliation: Mississippi State University
Address: 322 University Drive, Starkville, Miss. 39759
Phone: (601) 323-5783
Contact: Mike Clayborne
Additional information
Name: Jerry McDonald
Agency: Mississippi Department of Economic Development
Address: 1201 Sillers Building, 500 High Street, Jackson, Miss. 32901
Phone: (601) 354-7011

Oklahoma

Business conditions
Average construction costs (per square foot) $32
Percentage of new business started in 1985 in electronics 14%
State/local start-up assistance available for new business . . . . . Yes
Number of electronics companies. 164



Educational facilities
Number of four-year colleges and universities. 164
Additional information
Name: Grover Phillips
Agency: Industrial Division, Department of Commerce
Address: 6601 Broadway Extension, Oklahoma City, Okla. 73116
Phone: (405) 521-2401

Tennessee

Business conditions
Average cost of industrial land (per acre) . . . . . $5,000-$25,000
Average construction costs (per square foot) . . . . . $2.77-$3.35
Number of state/local sponsored incubator programs 2
Percentage of new business started in 1985 in electronics 5.9%
Number of electronics companies. 275
Educational facilities
Number of four-year colleges and universities. 37
Industrial parks with university affiliations:
Industrial park: Tennessee Technology Corridor
University affiliation: University of Tennessee
Address: P.O. Box 23184, Knoxville, Tenn. 37933

Phone: (615) 966-2804
Contact: Dr. David A. Patterson

Additional information
Name: John M. Crothers
Agency: State of Tennessee Department of Economic and Community Development
Address: Rachel Jackson Building, 6th floor, Nashville, Tenn. 37219
Phone: (615) 741-2994

Texas

Business conditions
Average cost of industrial land (per acre) . . . . . $20,000-$112,400
Average construction costs (per square foot) $46
Percentage of new business started in 1985 in electronics 3.5%
State/local start-up assistance available for new business . . . . . Yes
Number of electronics companies . . . 4,926

Educational facilities
Number of four-year colleges and universities 136
Industrial parks with university affiliations:
Industrial park: Texas A&M University Research Park
University affiliation: Texas A&M University
Address: College Station, Texas 77843
Phone: (409) 845-7275
Contact: Mark Mooney or John Millhollon
Industrial park: River Bend Industrial Park
University affiliation: Advanced Robotics Research Institute
Address: 2501 Gravel Drive, Fort Worth, Texas 76118
Phone: (817) 589-2200
Contact: Jack Frederick

Additional information
Name: Jack Alexander
Agency: Texas Economic Development Commission
Address: P.O. Box 12728, Capitol Station, Austin, Texas 78711
Phone: (512) 472-5059

Midwest

Illinois

Business conditions
Average cost of industrial land (per acre) $5,000
Average construction costs (per square foot) $30
Number of state/local sponsored incubator programs 16
Percentage of new business started in 1985 in electronics 13%
State/local start-up assistance available for new business . . . . . Yes
Number of electronics companies 992

Educational facilities
Number of four-year colleges and universities 179
Industrial parks with university affiliations:
Industrial park: Evanston-University Research Park
University affiliation: Northwestern University
Address: 2100 Ridge Avenue, Evanston, Ill. 60204
Phone: (312) 866-2936
Contact: Judith Aiello

Additional information
Name: Sharon Sharp
Agency: Department of Commerce and Community Affairs
Address: State of Illinois Center, 100 W. Randolph, Suite 3-400, Chicago, Ill. 60601
Phone: (312) 917-6306

Indiana

Business conditions
Number of state/local sponsored incubator programs 5

Percentage of new business started in 1985 in electronics 10%
State/local start-up assistance available for new business . . . . . Yes
Number of electronics companies 99

Educational facilities
Number of four-year colleges and universities 65
Industrial parks with university affiliations:
Industrial park: Purdue Industrial Research Park
University affiliation: Purdue University
Address: Hovde Hall, West Lafayette, Ind. 47907
Phone: (317) 494-8642
Contact: Winfield F. Hentshel
Industrial park: Indiana University Research Park
University affiliation: Indiana University
Address: 104 Bryan Hall, Bloomington, Ind.
Phone: (812) 335-8913
Contact: Dr. Morton Lowengrub
Industrial park: Aleph Park
University affiliation: Indiana State University & Rose Hulman University
Address: 200 W. Campus Drive, Terre Haute, Ind. 47802
Phone: (812) 232-2208
Contact: Joseph Steele

Additional information
Name: Mark Akers
Agency: Department of Commerce, Industrial Development Division
Address: One North Capitol Plaza, Suite 700, Indianapolis, Ind. 46204-2288
Phone: (317) 232-8888

Iowa

Additional information
Name: Craig Hamilton
Agency: Iowa Development Commission
Address: 600 E. Court Street, Des Moines, Iowa 50309
Phone: (515) 281-5979

Kansas

Business conditions
Average cost of industrial land (per acre) $30,000
Average construction costs (per square foot) $55
Percentage of new business started in 1985 in electronics 10%
State/local start-up assistance available for new business . . . . . Yes
Number of electronics companies 146

Educational facilities
Industrial park: University Corporate Research Park
University affiliation: University of Kansas
Address: P.O. Box 581, 823 Vermont, Lawrence, Kan. 66044
Phone: (913) 843-4411
Contact: William A. Martin
Industrial park: Foundation Techni-Park
University affiliation: Kansas State University
Address: P.O. Box 988, 505 Poyntz Avenue, Manhatten, Kan. 66502
Phone: (913) 776-8829
Contact: Mike Hauser
Industrial park: Comotara Industrial Park
University affiliation: Wichita State University
Address: 350 W. Douglas, Wichita, Kan.
Phone: (316) 265-7771
Contact: Ed Roberts

Additional information
Name: Bill Thompson
Agency: Kansas Department of Economic Development
Address: 400 W. 8th Street, Capitol Towers, Topeka, Kan. 66603
Phone: (913) 296-3483

Michigan

Business conditions
Average cost of industrial land (per acre) . . . . . $3,000-$100,000
Average construction costs (per square foot) $127
Number of state/local sponsored incubator programs 20
State/local start-up assistance available for new business . . . . . Yes
Number of electronics companies 462

Educational facilities
Number of four-year colleges and universities 15

Industrial parks with university affiliations:
Industrial park: Huron Center
University affiliation: Eastern Michigan State University
Address: Ypsilanti Township, Mich. 48197
Phone: (313) 761-9317
Contact: Mike Amman
Industrial park: Superior Technology Park
University affiliation: University of Michigan
Address: Superior Township, Mich. 48104
Phone: (313) 761-9317
Contact: Mike Amman
Industrial park: Ann Arbor Technology Park
University affiliation: University of Michigan
Address: Ann Arbor Township, Mich. 48106
Phone: (313) 761-9317
Contact: Mike Amman
Industrial park: Hannah Technology and Research Center
University affiliation: Michigan State University
Address: East Lansing, Mich. 48823
Phone: (517) 351-2480
Contact: Eyde Construction Co.
Industrial park: Oakland Technology Park
University affiliation: Oakland University, Oakland County Community College
Address: Auburn Hills, Mich. 48057
Phone: (313) 858-0732
Contact: Jeffery Kaczmarek
Industrial park: University Park
University affiliation: Central Michigan University
Address: Mount Pleasant, Mich. 48858
Phone: (517) 772-2858
Contact: George Dunn

Additional information

Name: Greg Main
Agency: Manufacturing Services
Address: P.O. Box 30225, Lansing, Mich. 48909
Phone: (517) 373-3550

Minnesota

Additional information

Name: Harry Rosefelt
Agency: Department of Energy and Economic Resources
Address: 900 American Center Building, 150 E. Kellogg Boulevard, St. Paul, Minn. 55101
Phone: (612) 296-5010

Missouri

Business conditions

Average cost of industrial land (per acre) . . . . . $4,000-$35,000
Average construction costs (per square foot) . . . . . $19-$35
Number of state/local sponsored incubator programs 5
Percentage of new business started in 1985 in electronics 8.5%
State/local start-up assistance available for new business . . . . . Yes
Number of electronics companies 278

Educational facilities

Number of four-year colleges and universities 88
Industrial parks with university affiliations:
Industrial park: The Research Park
University affiliation: University of Missouri-Columbia
Address: University of Missouri, 202 Jesse Hall, Columbia, Mo. 65211
Phone: (314) 882-6311
Contact: Dean Don H. Blunt
Industrial park: Missouri Research Park
University affiliation: University of Missouri-St. Louis
Address: University of Missouri, 225 University Hall, Columbia, Mo. 65211
Phone: (314) 882-6311
Contact: L. Thomas Hussey
Industrial park: UMKC North Campus Development Project
University affiliation: University of Missouri-Kansas City
Address: University of Missouri, 225 University Hall, Columbia, Mo. 65211
Phone: (314) 882-6311
Contact: L. Thomas Hussey

Additional information

Name: Ed Martin
Agency: Missouri Department of Economic Development
Address: P.O. Box 118, Jefferson City, Mo. 65102
Phone: (314) 751-4539

Nebraska

Business conditions

Average cost of industrial land (per acre) . . . . . $0-$152,460
Average construction costs (per square foot) $34
Number of state/local sponsored incubator programs 1
Percentage of new business started in 1985 in electronics 7%
State/local start-up assistance available for new business . . . . . Yes
Number of electronics companies 73

Educational facilities

Number of four-year colleges and universities 19

Additional information

Name: Bob Lewis
Agency: Recruitment Division, Nebraska Department of Economic Development
Address: P.O. Box 94666, Lincoln, Neb. 68509
Phone: (402) 471-3111

North Dakota

Additional information

Name: James Boyd
Agency: Office of Intergovernment Assistance
Address: State Capitol, 14th floor, Bismarck, N.D. 58505
Phone: (701) 224-2467

Ohio

Additional information

Name: Keith Ewald
Agency: Ohio Data User Center/Development Office
Address: 30 E. Broad Street, 26th floor, P.O. Box 1001, Columbus, Ohio 43266-0101
Phone: (614) 466-2480

South Dakota

Business conditions

Average cost of industrial land (per acre) $10,000
Average construction costs (per square foot) . . . . . $17-$22
Number of state/local sponsored incubator programs 1
Percentage of new business started in 1985 in electronics 18%
Number of electronics companies 158

Educational facilities

Number of four-year colleges and universities 12

Additional information

Agency: Department of State Development
Address: Capitol Lake Plaza, P.O. Box 6000, Pierre, S.D. 57501
Phone: 605-773-5032

Wisconsin

Business conditions

Average cost of industrial land (per acre) $6,000
Average construction costs (per square foot) . . . . . $18-$50
Number of state/local sponsored incubator programs 6
Percentage of new business started in 1985 in electronics 6%
State/local start-up assistance available for new business . . . . . Yes
Number of electronics companies 345

Educational facilities

Number of four-year colleges and universities 42
Industrial parks with university affiliations:
Industrial park: University Research Park
University affiliation: University of Wisconsin-Madison
Address: 945 WARF Building, 610 Walnut Street, Madison, Wis.
Phone: (608) 238-8670
Contact: Wayne McGown

Additional information
Name: Rolf Wegenke
Agency: State of Wisconsin Department of Development, Division of Economic and Community Development
Address: State Justice Building, P.O. Box 7970, 123 W. Washington Avenue, Madison, Wis. 53707
Phone: (608) 266-3203

Mountain

Arizona

Business conditions
Average construction costs (per square foot) $25
Number of state/local sponsored incubator programs . . . . . None
Percentage of new business started in 1985 in electronics 4%
State/local start-up assistance available for new business . . . . . Yes
Number of electronics companies 280

Educational facilities
Number of four-year colleges and universities 19
Industrial parks with university affiliations:
Industrial park: Arizona State University Research Park
University affiliation: Arizona State University
Address: 2105 E. Elliott Road, Tempe, Ariz. 85284
Phone: (602) 965-2105
Contact: Reginald W. Owens
Additional information
Name: Janice M. Schaefer
Agency: Arizona Department of Commerce
Address: 1700 West Washington, Phoenix, Ariz. 85007
Phone: (602) 255-5374

Colorado

Additional information
Name: Steve Schmidt
Agency: Commerce and Development Division
Address: 1313 Sherman Street, Room 523, Denver, Colo. 80203
Phone: (303) 866-5491

Idaho

Business conditions
Average cost of industrial land (per acre) $45,000
Average construction costs (per square foot) $50
Number of state/local sponsored incubator programs 5
Percentage of new business started in 1985 in electronics 3.3%
State/local start-up assistance available for new business . . . . . Yes
Number of electronics companies 62
Educational facilities
Number of four-year colleges and universities 6
Industrial parks with university affiliations:
Industrial park: ISU Research and Business Park
University affiliation: Idaho State University
Address: P.O. Box 8044, Pocatello, Idaho 83209
Phone: (208) 236-2430
Contact: Dr. Les Purce
Industrial park: Simplot-Micron Technology Center
University affiliation: Boise State University
Address: 1910 University Drive, Boise, Idaho 83725
Phone: (208) 385-3289
Contact: Ben Hambelton
Additional information
Name: Jay Engstrom
Agency: Department of Commerce
Address: State Capitol Building, Room 108, Boise, Idaho 83720
Phone: (208) 334-4719

Montana

Additional information
Name: Bill Duffy
Agency: Department of Commerce
Address: 1424 Ninth Avenue, Helena, Mont. 59620
Phone: (406) 444-3923

Nevada

Additional information
Name: Jean Towne
Agency: Commission of Economic Development
Address: Capitol Complex, 600 E. Williams, Suite 203, Carson City, Nev. 98701
Phone: (702) 885-4325

New Mexico

Business conditions
Number of electronics companies 30
Educational facilities
Number of four-year colleges and universities 2
Additional information
Name: Terry Allbrooks
Agency: Albuquerque Economic Development Inc.

JANUARY IN

Electronic Business

January 1

- Outlook 1987 Special Feature
- Market Strategies:
  Automatic Test Equipment
  CAD/CAM/CAE
  Semiconductors
  Computers, Peripherals, Software
  Production/Process Equipment
  Components
- Managing Technology:
  Image Processing
- U.S. Regional Plant Site
- Business Barometer:
  Revenues & Profits
  Automatic Test Equipment

Advertising Deadline: December 3, 1986

January 15

- Military Electronics
- Bus Wars
- Distributor Strategies
- Electronics Factory of the Future:
  Automatic Test Equipment for Printed Circuit Boards
- Business Barometer:
  Passive Components
  Communications

Advertising Deadline: December 17, 1986

A CAHNERS PUBLICATION
275 WASHINGTON STREET
NEWTON, MA 02158
(617) 964-3030

Address: P.O. Box 25100, Albuquerque, N.M. 87125
Phone: (508) 842-0400

Utah

Business conditions
Average cost of industrial land (per acre) $75,000
Average construction costs (per square foot). . . . . $21-$38
State/local start-up assistance available for new business . . . . . Yes
Number of electronics companies. 260

Educational facilities
Number of four-year colleges and universities. 4
Industrial parks with university affiliations:
Industrial park: University of Utah Research Park
University affiliation: University of Utah
Address: 391 Chipeta Way, Salt Lake City, Utah 84108
Phone: (801) 581-8133

Additional information
Name: Howard Bird
Agency: Department of Community and Economic Development
Address: 6150 State Office Building, Salt Lake City, Utah 84114
Phone: (801) 533-5325

Wyoming

Additional information
Name: John Logan
Agency: Economic Development and Stabilization Board
Address: The Herschler Building, 3rd floor, East Wing, Cheyenne, Wyo. 82002
Phone: (307) 777-7284

Pacific

Alaska

Additional information
Name: Paul Fletcher
Agency: Department of Commerce Office of Enterprise
Address: State Office Building, Pouch D, Juneau, Alaska 99811
Phone: (907) 465-2018

California

Business conditions
Average construction costs (per square foot): $50

Educational facilities
Number of four-year colleges and universities: 328

Additional information
Name: Don Backstrom
Agency: Industrial Development Financial Advisory Commission
Address: 915 Capitol Mall, Room 280, Sacramento, Calif. 95814
Phone: (916) 445-9597

Hawaii

Additional information
Name: Cornelius Downes
Agency: Planning and Economic Development Department
Address: 250 South King Street, 7th floor, Honolulu, Hawaii 96804
Phone: (808) 548-4620

Oregon

Business conditions
Average cost of industrial land (per acre) . . . . . $5,000-$85,000
Average construction costs (per square foot) . . . . . $0.18-$0.75

Number of state/local sponsored incubator programs 4
State/local start-up assistance available for new business . . . . . Yes
Number of electronics companies. 368

Educational facilities
Number of four-year colleges and universities. 27
Industrial parks with university affiliations:
Industrial park: Oregon Graduate Center Science Park
University affiliation: Oregon Graduate Center
Address: 1600 N.W. Compton Drive, Suite 300, Beaverton, Ore. 97006
Phone: (503) 690-1121
Contact: Dr. F. Paul Carlson

Additional information
Name: Thomas F. Kennedy
Agency: Oregon Economic Development Department
Address: 595 Cottage Street N.E., Salem, Ore. 97310
Phone: (503) 373-1200, 1-800-547-7842

Washington

Additional information
Name: John Anderson
Agency: Commerce and Economic Development Department
Address: General Administration Building, Olympia, Wash. 98504
Phone: (206) 753-7426

Use the card on the facing page to get FREE information on plant sites and facilities

Write these numbers in the boxes on the response card.

1. **Bavaria, State Ministry of Economics**...(page 95)
2. **Bristol Chamber of Commerce**...(page 66)
3. **Dawson Creek Business Park**...(page 109)
4. **ITT Community Development Corp**....(page 84)
5. **Indiana Department of Commerce, Industrial Development**...(page 97)
6. **Northern Rhode Island Marketing Council**... (page 118,119)
7. **Scottish Development Agency**...(page 90)

Use this card

FROM **Electronic Business**
SEND FOR YOUR COPIES TODAY

Keeping the Competitive Advantage

The McKinsey & Co. Series on Managing Technology Companies

The IBM EMPIRE

The much-requested series of articles on the one company whose business is everybody's business

To order, send a check for $15 each, payable to ELECTRONIC BUSINESS. No orders can be processed without payment

☐ Keeping the Competitive Advantage
☐ **The IBM EMPIRE**

Name
Company
Address
City/State/Zip

ELECTRONIC BUSINESS
275 Washington Street
Newton, Mass. 02158